New Scientist

WEEKLY 24 February 2024

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WHY YOU DON'T NEED TO PANIC ABOUT ULTRA-PROCESSED FOODS

DID COSMIC DUST DELIVER LIFE'S INGREDIENTS TO EARTH?

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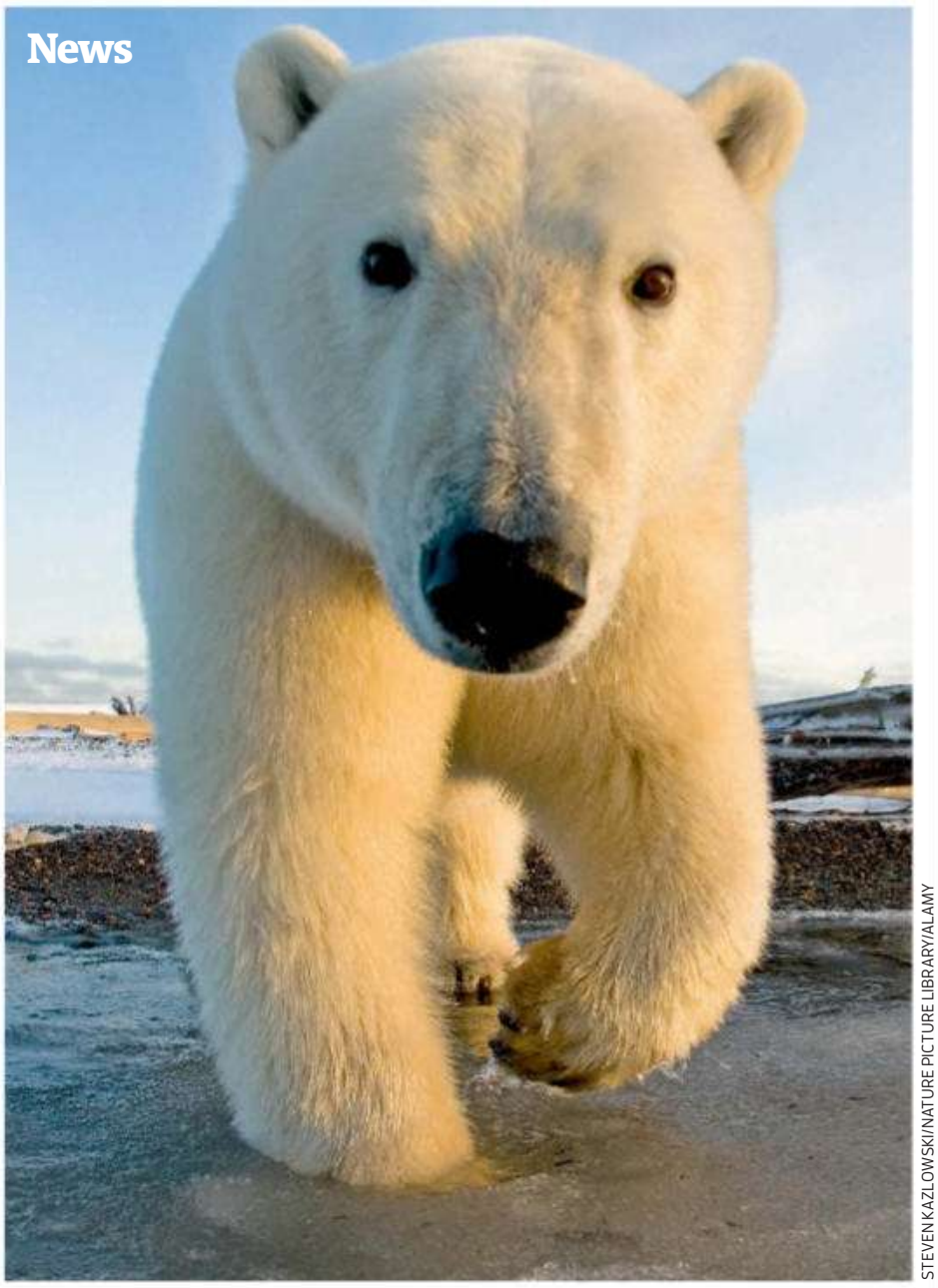

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Ten challenging questions that highlight the most intriguing new discoveries about our minds, including: Are male and female brains actually different? Are there different states of consciousness? Does your brain have a microbiome? And is your brain the most complex object in the universe? Find out the secrets still lurking in our most enigmatic organ.

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Instant Expert

Revealing the mysteries of matter

By slamming atoms together at ever higher energies, physicists have discovered an intricate web of fundamental forces and particles. But we know that this picture of reality – called the standard model of particle physics – is incomplete. Join six leading experts at London's Conway Hall on 13 April to find out everything we know so far about what stuff is made of.

newscientist.com/events

Tour

Whale watching in the Azores: Portugal

Search for blue whales, sperm whales and several dolphin species in an archipelago packed with flora and fauna, volcanic craters, lagoons and picturesque towns. Take part in marine research and learn firsthand from oceanographer Russell Arnott. This seven-day trip starts on 7 May and costs £3399.

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Podcast

Weekly

The team discuss advances in beaming electrical power to Earth's surface from orbiting solar panels. They also learn about a new approach to treating blindness caused by conditions that damage the optic nerve, such as glaucoma. Hear some of the best love languages from the animal world. Plus, black holes that spin slower than previously thought and the microbes that are the secret to tasty tea.

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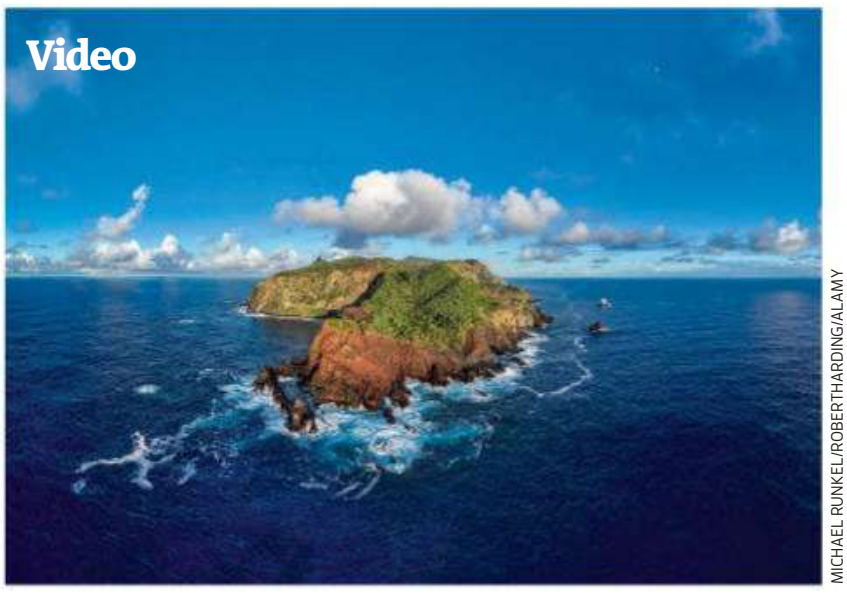
TRACZYK, PIOTR/CERN

Atom smashers Do new particles lie beyond the energy frontier?



MICHAEL RUNKEL/ROBERTHARDING/ALAMY

Safe haven The Pitcairn Marine Reserve is three times the UK's area

Video

Protecting the Pitcairns

New Scientist staff writer Graham Lawton travelled to the remote Pitcairn Islands in the Pacific Ocean to understand how they are helping the UK exceed its share of a pledge to protect 30 per cent of the global ocean. The waters surrounding the islands are one of the world's most successful marine protected areas and a glittering example of how to do ocean conservation well.

youtube.com/newscientist

Newsletter

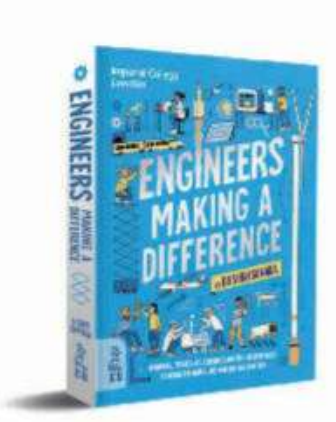
Hunting debunked

Trophy hunting is one of conservation's most divisive issues. Some claim that it does more good than harm by generating revenue that can be funneled into conservation. On the other hand, critics argue that it is a cruel colonial relic with no positive impact. Penny Sarchet weighs up the evidence.

newscientist.com/wild-wild-life

Newsletter

"It's ridiculous to calculate the economic value of a standardised elephant, alive versus dead"



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What's the difference?

Understanding brain divergence between the sexes could improve mental health

WE'VE heard it all. Male brains are bigger and better at spatial awareness. Female brains are geared to multitasking and emotional intelligence. Stereotypes of how sex influences behaviour abound, and as increasingly sophisticated brain-scanning techniques appear, more claims of such disparities have come to light.

But, as we discover in our 12-page special on the human brain (see page 32), trying to identify a biological reason for population differences in men's and women's behaviours, interests and occupations is a nuanced debate that encompasses gender as well as sex, and is in no way settled.

Nevertheless, we should continue to try. Not least because if there really are sex-based brain differences, it would have huge implications for our health. That's because many medical conditions involving the brain and neurodivergence affect the sexes at different rates and in different ways. For instance, women have higher rates of depression, anxiety and eating disorders. Men have higher rates of autism and attention deficit hyperactivity disorder.

"Sex-based brain differences could stem from the way society treats men and women"

There could be many reasons for these skewed sex ratios: autism may be being underdiagnosed among girls or they may manifest typical behaviours differently, for example. Likewise, depression may be higher in women due to biological factors, because women tend to earn less money or because men are less likely to seek help for mental health problems.

But there could also be sex-based brain differences. If there are, the picture still isn't complete. These might not be due to direct genetic influences or the effects of sex hormones, but could stem from the way society generally treats men and women differently throughout life.

Unravelling all of this could shed light on the mechanisms behind these conditions, leading to better treatment strategies. Ultimately, then, it is an endeavour that isn't about pitting male and female brains against each other, but one that has the potential to help everybody. ▮

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Black holes spew gas so hard they almost stop spinning p18

Space

A selfie with the blue planet

Intuitive Machines's robotic Odysseus spacecraft beamed back this selfie with Earth on 16 February, a day after launching on a SpaceX Falcon 9 rocket. As *New Scientist* went to press, Odysseus was due to land near the lunar south pole on 22 February. Its payload of experiments will collect data for NASA's Artemis programme, which includes plans to put a crewed base on the moon.

INTUITIVE MACHINES

Medicine

Stem cells grown for experimental therapies pose a cancer risk

Clare Wilson

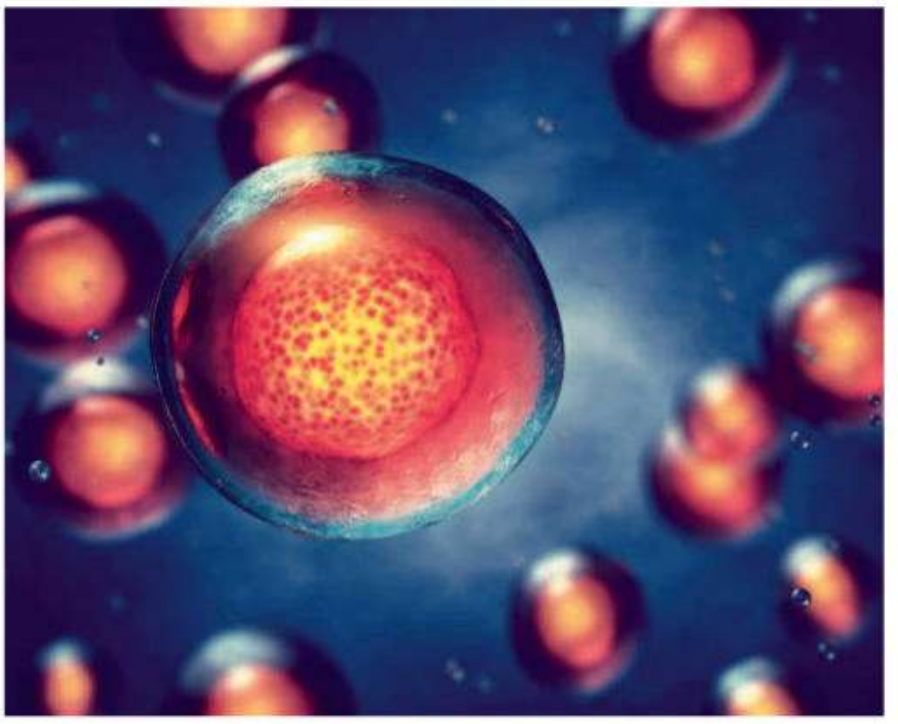
A KIND of stem cell transplant that has long been seen as one of the most promising new medical treatments could bring a greater risk of cancer than we previously thought. A study has found that more than a fifth of stem cells being grown in laboratories for regenerative medicine research harbour cancer-causing mutations.

The cells tested haven't been put into people, but were being used in research to explore their medical use. The findings show that multiplying cells in a dish can cause the dangerous mutations to develop, says Nissim Benvenisty at the Hebrew University of Jerusalem. "These are exactly the same mutations you find in human tumours."

Stem cells that are being studied for regenerative medicine are "pluripotent", which means they are similar to those in a developing embryo, with the potential to multiply and turn into different kinds of tissues. They are usually obtained either from unneeded embryos made during in vitro fertilisation (IVF) or by taking cells from an adult, for instance skin cells, and administering certain chemical signalling molecules.

The hope is to find new treatments for a huge range of medical conditions by making these cells develop into specialised kinds – such as those of the heart, kidneys or eyes – and then implanting them into the body to replace damaged or diseased organs.

None has yet been approved for routine use, although there are many ongoing clinical trials. Clinics in some countries, such as Mexico and Russia, also offer unregulated treatments, leading to stem cell tourism.



NOBEASTSOFIERCE SCIENCE/ALAMY

Stem cells are being studied for the treatment of many medical conditions

Benvenisty and others have previously shown that stem cells grown in the lab can harbour cancerous mutations. To find out how common they are, the team has re-analysed studies that investigated the genes of 146 collections of stem cells used by various universities around the world.

In 22 per cent of the samples, there was at least one mutation in a gene that can cause cancer when mutated in people. One of the most commonly affected was the *p53* gene, mutations in which are behind many human tumours (*Nature Biotechnology*, doi.org/mhb5).

22%

Proportion of samples with potential cancer mutations

Once mutations arise that let cells multiply faster, mutated cells may outcompete other cells and take over the dish, although they probably need several mutations to become a tumour, says Benvenisty.

The findings don't mean the stem cells can't be used as therapies, but it shows we need to take steps to make sure researchers don't transplant cancerous cells into someone's body, he says. As a precaution, Benvenisty says researchers should keep cells in a dish for as short a time as possible, because each cell division gives a chance for new mutations to arise.

There have been a few reports of people getting tumours after stem cell treatment, such as in 2022, when a patient at Yunnan Cancer Hospital in China developed an aggressive form of cancer from an implant aimed at treating his type 1 diabetes.

Ivana Barbaric at the University of Sheffield, UK, says researchers need to agree on standardised ways of checking stem cell treatments for mutations. "This is a concern, but we still want to ensure that cell therapies progress to the clinic," she says. ▮

Zoology

Polar bears seem to be ageing faster as the Arctic warms

James Woodford

THE stress of climate change appears to be making polar bears today age at a faster rate than those born just over half a century ago.

Levi Newediuk at the University of Manitoba, Canada, and his colleagues assessed the health of polar bears (*Ursus maritimus*) in Hudson Bay, Canada, by looking at chemical tags that accumulate on DNA, known as epigenetic markers. These markers are influenced by environmental factors, including stress, and regulate the activity of genes. Some of them can be used to estimate an animal's biological age.

Using recent tissue samples in addition to archived ones from individuals with known chronological ages, the researchers looked for differences in cellular ageing in polar bears over a 40-year period, in which the Arctic has warmed by approximately 3°C and the ice-free period has gradually lengthened, reducing the time polar bears have to hunt on the ice.

They found that bears born since 2010 have a biological age that is on average 2.6 years greater than those with the same chronological age born in the 1960s (bioRxiv, doi.org/mhb4).

By analysing genetic changes in the population over time, Newediuk and his colleagues also found that the Hudson Bay bears don't seem to be adapting to climate change. "The western Hudson Bay polar bear population faces an uncertain future," they write. The population numbers about 600 individuals.

Polar bears face many challenges, including climate change, disease and pollution, which could all affect epigenetic ageing, says Andrew Derocher at the University of Alberta, Canada. "Ultimately, however, these sorts of genetic changes are likely less impactful than the direct mortality and loss of reproductive output that results from a longer ice-free period," he says. ▮

Physics

New kind of magnetism revealed

Altermagnets could make it easier to cram data onto computer hard drives

Alex Wilkins

A NOVEL kind of magnetism has been witnessed for the first time. Altermagnets, which have a mix of properties from different classes of magnets, could be used to make high-capacity memory devices or new kinds of magnetic computers.

Until the 20th century, there was thought to be only one kind of permanent magnet, a ferromagnet, the effects of which can be seen in compass needles. The electrical fields of such magnets are caused by their electrons' magnetic spins lining up in one direction.

But, in the 1930s, French physicist Louis Néel discovered antiferromagnetism, where the electrons' spins are alternately up and down. Then, in 2019, researchers predicted an electric current in the crystal structure of some antiferromagnets, called the anomalous Hall effect, which couldn't be explained by alternating spins alone. The current was moving without any external magnetic field.

It seemed, when looking at a crystal in terms of "sheets" of spins in any one plane, that a third kind of permanent magnetism might be responsible, which has been called altermagnetism. Altermagnets would look like antiferromagnets,

"The magnets could lead to spintronic computers that use magnetic spin instead of electric current"

but the sheets of spins would look the same when rotated from any angle. Yet no one had seen the electronic signature of this structure itself, so scientists were unsure whether it was definitely a new kind of magnetism.

Now, Juraj Krempaský at the Paul Scherrer Institute in Villigen, Switzerland, and his colleagues have confirmed the existence of an altermagnet by measuring the electron structure in a crystal, manganese telluride, previously thought to be antiferromagnetic.

To do this, they gauged how light bounced off manganese telluride to find the energies and speeds of the electrons inside the crystal. After mapping out these electrons, the team found they almost exactly matched the predictions given by simulations for an altermagnetic material.

The electrons seemed to be split into two groups, which allows them more movement inside the crystal and is the source of the unusual altermagnetic properties (*Nature*, doi.org/mhb3). "This gave direct evidence that we can talk about altermagnets and that they behave exactly as predicted by theory," says Krempaský.

The electron grouping seems to come from the atoms of tellurium (which is non-magnetic) in the crystal, which separate the magnetic charges of the manganese into their own planes and allow the unusual rotational symmetry.

"It's really nice verification that these materials do exist," says Richard Evans at the University of York, UK. Because altermagnets don't have external magnetic fields, you could use them to make magnetic devices that don't interfere with each other, he says.

The property could boost computer hard drive storage: ferromagnetic material can only be packed so tightly before the external magnetic fields start to interfere, but altermagnets could be fitted in more densely.

The magnets could also lead to spintronic computers that use magnetic spin instead of electric current to perform their calculations, says Joseph Barker at the University of Leeds, UK. ▮

Food science

Genetically modified bananas approved for the first time

REGULATORS in Australia and New Zealand have given the go-ahead to a genetically modified strain of banana altered to be resistant to a fungal disease. It is the first time a modified banana has been approved for growing on farms.

The Office of the Gene Technology Regulator in Australia issued a licence permitting the commercial growth of the modified banana on 12 February. On 16 February, Food Standards Australia New Zealand approved it as a food, concluding that it is as safe and nutritious as conventional bananas.

The first banana to be widely eaten in Western countries was a variety called Gros Michel. But by the 1950s, the spread of a *Fusarium* fungus strain called tropical race 1 (TR1), which causes Panama disease, forced farmers to switch to the Cavendish banana. Although it reportedly doesn't taste as nice as the Gros Michel, the Cavendish is highly resistant to TR1.

FAIRFAX MEDIA VIA GETTY IMAGES

Conventional bananas grown in a plantation in Queensland, Australia

Now, another strain of *Fusarium*, called TR4, is spreading worldwide. It can kill many banana varieties, including the Cavendish.

A team led by James Dale at the Queensland University of Technology, Australia, created the resistant strain of Cavendish banana, called QCAV-4, by adding a gene from a wild banana.

This decision is "a very important step towards building a safety net for the world's Cavendish bananas from TR4 which has impacted many parts of the world already", Dale said in a statement.

In Australia, quarantine measures are limiting TR4's spread to a small number of outbreaks each year, so, for now, there are no plans to grow the QCAV-4 banana on a large scale or to sell it to consumers. However, countries where TR4 is more of a problem may decide to adopt the genetically modified banana. ▮

Michael Le Page

Food science

Super-thickeners made of starch could cut calorie content

Karmela Padavic-Callaghan

BUILDING tiny sheets and cages from starch particles turns them into super-thickeners that could reduce the calorie content of foods.

Starch is often added to things like soups to make them richer and thicker, but doing so increases the calorie count and carbohydrate content. Starch particles thicken food because they swell up when they are heated, leaving less room for liquid in the dish to flow freely.

Peilong Li at Cornell University in New York and his colleagues wondered if they could replicate this effect, yet cut the amount needed by hollowing out such particles. "But you can't just carve a starch granule like it's a pumpkin," says Li.

Working with starch particles from amaranth grain, the team assembled them into three-dimensional shapes by mixing them with water and oil. The particles arranged themselves around oil drops, and then the team removed the two liquids by heating and freeze-drying. This left just the starchy structures, some shaped like hollow cages, some like sheets that would cascade on top of each other so liquids would get trapped between them.

The team found that these structures performed so well as thickening agents that they could be used to halve the amount of starch typically needed to thicken foods (*Science Advances*, doi.org/mhbh).

Fan Zhu at the University of Auckland in New Zealand says that using these granules as building blocks for hollow starch structures could make starches a big part of designing future foods. However, Zhu says sourcing them from amaranth is expensive, so adapting the method to more affordable and abundant versions, like those made from corn, would be good. "And more studies are needed on what happens when you put this kind of structure in your mouth," he says. ▮

Environment

Container ship tests system to capture its own emissions

James Dinneen

A 240-METRE-long cargo ship called the Sounion Trader recently completed a test of an onboard carbon-capture system as it cruised around the Persian Gulf. It is one of a small number of vessels trying to reduce their climate footprint by capturing and storing their carbon dioxide emissions onboard – but finding space to do this is a challenge.

1000

Number of ships Seabound wants to fit for carbon capture

"You're miniaturising a system that was designed for huge power plants," says Roujia Wen at Seabound, the UK-based start-up behind the Sounion Trader's test run.

Shipping is responsible for about 3 per cent of global CO_2 emissions. To reduce that, some operators are using cleaner fuels, lubricating hulls with bubbles to cut drag and even installing sails. But near-term options to reach the industry's pledge of net-zero emissions by 2050 are limited.

Another possibility is capturing emissions and storing them onboard, but this faces obstacles. One is supplying the energy to recharge the chemical sorbents used to absorb CO_2. Tristan Smith at University College London says some systems increase fuel use by a third just to catch half of the CO_2 emissions.

The equipment, and the captured carbon, also take up room that would normally be used for valuable cargo. "Space is an issue," says Jasper Ros at TNO, a research organisation in the Netherlands. "Especially when you're talking about long voyages." Each tonne of combusted fuel forms about 3 tonnes of CO_2, says George Mallouppas at the Cyprus Marine & Maritime Institute. When captured and stored, the added mass can affect a ship's stability and reduce its fuel efficiency.

Wen says Seabound's small-scale tests captured about a tonne of CO_2 per day. That is a small fraction of the ship's overall emissions, but she says the full-scale system will be able to capture as much as 95 per cent of a ship's CO_2.

About 3 per cent of all carbon emissions are due to the shipping industry

GREENOAK/SHUTTERSTOCK

To save energy, Seabound moves part of its process onshore. On the ship, exhaust is looped through a calcium oxide sorbent, which reacts with CO_2 to form calcium carbonate pebbles. The company then waits until the pebbles are offloaded at port for permanent storage before recharging the sorbents. Space remains an issue. Seabound's approach means a ship must carry tanks of sorbent along with the captured CO_2. Still, Wen says the company aims to retrofit 1000 ships for carbon capture by 2030.

A Dutch company called Value Maritime is taking a similar approach, using a liquid amine sorbent to capture CO_2 and then recharging it offshore. Yvette van der Sommen at Value Maritime says 26 ships are now using its system alongside existing sulphur pollution scrubbers to capture up to 40 per cent of the CO_2 in the exhaust, although the process hasn't yet been certified by a third party. She says the firm has sold some captured CO_2 to greenhouses to fertilise plants, but much of it remains stored in tanks at ports.

Such systems may seem attractive for cutting shipping emissions now, says Smith. But the scale-up of production of cleaner shipping fuels may soon make them obsolete – unless the systems achieve high rates of capture at a low-enough cost. "Shipping faces a very short time to decarbonise because it has started so late," he says. ▮

Space

Is cosmic dust key to life's origins?

Key ingredients for early life may have been delivered to glacial ponds from space

Leah Crane

DUST falling from space may have brought crucial elements for life to early Earth. Our planet is relatively poor in several elements necessary for the chemistry of life, but the material constantly drifting down from space has more and this could have collected in glacial areas when Earth was young.

"This has been kind of lingering as an idea in the shadows, but people had dismissed it for several reasons, the big one being that there wasn't enough of it in any one location," says Craig Walton at the University of Cambridge. Cosmic dust tends to be rich in elements such as phosphorus and sulphur that are relatively unavailable on Earth, and it falls constantly around the world.

In the past, researchers searching for the origin of such elements on Earth largely focused on larger objects like meteorites that could deliver more of them at once, but that sort of delivery mechanism could struggle to maintain prebiotic chemistry for long enough for life to arise, says Walton. "Meteorites deliver those elements randomly," he says. "You need a continuous source, and that's what cosmic dust is."

ALAN DYER/VWPICS/ALAMY

Dust-like micrometeorites come from things like the Geminid meteor shower

"This has been kind of lingering as an idea in the shadows, but people had dismissed it"

Up to 40,000 tonnes of this dust falls to Earth every year, some associated with meteor showers. Billions of years ago, that number would have been 10 to 10,000 times higher, but that still wouldn't have been enough to make any individual location particularly rich in the elements important to life. Walton and his colleagues performed simulations of how the dust could have been moved around by wind and water to collect in high enough concentrations to help spark life.

They found that the most promising environments were glaciers, both because they could trap lots of dust and because they have very little contamination from terrestrial dirt (*Nature Astronomy*, doi.org/mg95). When cosmic dust falls on a glacier, it absorbs sunlight and heats up, melting a small hole in the ice. The hole then traps more dust. Finally, the chamber of dust drains into ponds at the edge of the glacier.

We see this process today, but if Earth was cold enough to have glaciers billions of years ago, the higher volume of dust would have made it more efficient. "If you want to produce a sediment that's really rich and has lots of these reactions that could lead to life, this is the best way forward," says Walton.

"It's unclear whether glaciers were common on early Earth," says Ben Pearce at Johns Hopkins University in Maryland. "However, I think any possibility is worth studying, especially if it provides a mechanism for creating a rich primordial soup."

"We've always had trouble figuring out what the bulk chemistry of the early Earth would have been like," says Matthew Pasek at the University of South Florida. "But [cosmic dust] could be an important source of very valuable material." ▮

Zoology

Female scorpions don't mind being stung during sex

GETTING stung may help female scorpions evaluate suitors.

During scorpions' mating rituals, the male grabs the female's pincers to lead her in a dance and then rubs his tail gland over her, lathering her in secretions. If the female doesn't run away or eat him, he then places one to three stings into her, before transferring his sperm.

To investigate the stinging, Mariela Oviedo-Diego at the National University of Córdoba in Argentina and her colleagues collected 70 female and 130 male *Urophonius achalensis* scorpions, a South American species in the Bothriuridae family, from the Andes mountains. They placed male-female pairs into a glass "mating arena" and watched what occurred.

Faced with a female, 55 per cent of males shook with excitement – the first stage of courtship – and 53 per cent of courted females allowed the male to grab their pincers and start dancing. However, only one-third of the females stayed in the courtship to the end, with the male laying a sperm packet and pulling the female on top of it.

AGUSTIN ESMORIS/MINDEN PICTURES/ALAMY

Scorpions in the Bothriuridae family have elaborate courtship rituals

Females that stayed in the courtship remained mostly still while a male rubbed her with the gland near the tip of his tail. "We think this is a stimulating behaviour that makes the female more receptive," says Oviedo-Diego.

The females also showed little resistance as the male inserted his stinger into a softer body region, like the side of the abdomen (*Animal Behaviour*, doi.org/mg9h). "During that moment, the female is very quiet," says Oviedo-Diego. "But that doesn't mean that the female is passive. She is screening something there, like the quality of the male."

It is a compelling idea, says Callum McLean at the University of Aberdeen, UK. "If you can sting a lot, and for quite a long time", that indicates you have lots of energy and could sire good offspring, he says. ▮

Christa Lesté-Lasserre

Field notes Brooklyn, New York

The start-up making jet fuel with carbon dioxide

By rethinking a century-old process, captured emissions can be used to produce cleaner jet fuel, finds **James Dinneen**

IN A grey building in an industrial corner of Brooklyn, New York, Stafford Sheehan shows me a jar full of black metallic pellets. "This is the special sauce," he says. They don't look like much, but he says they could help produce billions of litres of fossil-free liquid fuel.

Sheehan's start-up, Air Company, is one of a growing set of manufacturers trying to use captured CO_2 to replace products currently made with fossil fuels, in a bid to reduce emissions. But Sheehan says his company's process is simpler and more energy efficient than competitors' thanks to rethinking a century-old process to turn CO_2 into fuel.

Next to us, a sleek system of tubes and pipes fills the room. On one side is a tank of CO_2 the size of a van and two boxy electrolysers, which make hydrogen using clean electricity to split water molecules. The hydrogen and CO_2 can react with each other thanks to a metal catalyst – the aforementioned "special sauce". The resulting liquid, after a refining step, flows into two tanks labelled AROMATICS and PARAFFINS. These are "the building blocks for almost all fuels", says Sheehan.

Cleaner sources

We are standing in the company's largest plant yet, capable of producing a few thousand litres of liquid fuels each year, most of which goes to the US military to be tested in aircraft. Sheehan says the facility is the blueprint for additional plants under development that could produce millions of litres a year. The company is also working on a NASA grant that might one day help astronauts make rocket fuel from Mars's CO_2-rich atmosphere.

Here on Earth, the aim is to reduce emissions. If the fuel manufacturing process uses clean electricity and CO_2 captured from the atmosphere, the result will be near carbon neutral. If CO_2 is captured from a source of emissions, the fuels won't be carbon neutral, but the product might still replace fossil fuels that emit even more CO_2 elsewhere.

Sustainable aviation fuels that can power existing jets are in especially high demand, and the shipping industry is also seeking cleaner sources of power, such as e-methanol. However, such synthetic fuels are expensive and require lots of energy to produce, most of which goes towards making hydrogen.

THE AIR COMPANY

Air Company's pilot facility in Brooklyn, New York

Normally, this hydrogen is first used to convert CO_2 into carbon monoxide (CO) in a reactor kept at high temperature and pressure. The CO and more hydrogen are then combined to make syngas, which is finally converted to hydrocarbon fuels using a metal catalyst in a second reactor. This last step is a mainstay of industrial chemistry known as the Fischer-Tropsch process, invented in the 1920s.

Sheehan's company squeezes all this activity into a single reactor by directly combining CO_2 with hydrogen, along with a solid catalyst that enables them to react under mild conditions to make hydrocarbons; a different catalyst is used to make ethanol.

He says this simplifies the process and takes about a fifth of the energy per litre of liquid fuel that is used by a conventional operation.

The composition of the catalysts is secret, and Air Company hasn't published enough information for outside researchers to assess its energy efficiency claims. But Sheehan sees the process replacing the one that relies on conventional Fischer-Tropsch. "It's about time we innovated on this 100-year-old technology," he says.

Air Company isn't alone in rethinking how fuels are made from carbon. A California-based firm called Twelve, which is constructing a large jet fuel plant in Washington state, produces its CO with a CO_2 electrolyser, rather than using hydrogen.

And Illinois-based LanzaTech just opened a plant in Soperton, Georgia, to make jet fuel out of ethanol made from waste.

These synthetic fuels could offset emissions, but making them will require lots of clean energy that could reduce emissions more if used elsewhere, says Robert Weber at Pacific Northwest National Laboratory in Washington state. Based on what Air Company has published, he is sceptical that their process saves much energy.

"It's about time we innovated on this 100-year-old technology"

Miguel Modestino at New York University, who is collaborating with Sheehan on the rocket fuel project, also doubts there are large energy efficiency benefits. "You still need the same number of hydrogen molecules," he says.

But he says the process with just one reactor could have the advantage of simplicity. That could lower the barriers to making fuel from CO_2, whether in Brooklyn or on Mars. ▮

THE AIR COMPANY

This solid catalyst helps carbon dioxide and hydrogen react more easily

Health

Cell regeneration brings back sight

Vision has been restored in mice with damaged optic nerves, raising hope for glaucoma treatment

Michael Le Page

THE vision of mice with damaged optic nerves has been partly restored by generating new nerve cells in the eye to replace ones that died. The hope is this approach could help treat people with conditions that cause blindness by damaging the optic nerve, such as glaucoma.

"We can regenerate those cells," says Biraj Mahato at the Children's Hospital Los Angeles. But more studies in larger animals will have to be done before trials in people can be considered, he says.

Glaucoma is one of the most common causes of blindness worldwide, affecting some 80 million people. It damages the optic nerve that carries information from the eyes to the brain. The progress of the condition can be halted once diagnosed, but often it is detected only after there is a significant loss of sight. At present, there is no way to restore lost vision.

Various teams around the world are working on ways to replace the nerve cells in the optic nerve, called retinal ganglion cells, that die as a result of glaucoma. The main bodies of retinal ganglion cells are found in the retina, but they have long projections, called axons, that extend all the way to the brain.

One idea for restoring vision lost because of glaucoma is to generate new retinal ganglion cells from stem cells in a lab and transplant them into the eye.

Mahato and his colleagues are instead coaxing existing cells within the eye to turn into nerve cells. They have developed a cocktail of eight chemicals that induce support cells known as Müller glia to turn into what appear to be retinal ganglion cells.

When the researchers tested the cocktail in mice whose optic nerves had been chemically damaged, they saw signs of vision recovery starting after two weeks and continuing for at least four months.

One test involved mice walking across a transparent surface with an apparent drop underneath one side, known as the visual cliff experiment. Almost all the non-glaucoma mice chose to walk on the side with no visual drop, but this preference didn't occur in those with damaged optic nerves. However, 45 days after treatment, 72 per cent of the treated mice chose the safer-looking side.

"One test involved mice walking on a transparent surface with an apparent drop underneath"

The researchers did other studies to confirm that the new retinal ganglion-like cells had developed from Müller glia and that they were extending axons towards the brain. They also showed that the cocktail turned human Müller glia growing in a dish into retinal ganglion-like cells (bioRxiv, doi.org/mgz3).

Mahato thinks this approach has advantages over growing cells for transplantation. It is very quick and means there are no issues with immune rejection, he says.

"It is an approach worth pursuing," says Ted Garway-Heath at the UCL Institute of Ophthalmology in the UK. But there is much to be done before human trials, he says, and it isn't guaranteed to work in people, in part because human axons have to grow further to reach the brain than those in mice do.

Food science

Microbes on plant roots change the taste of your tea

TWEAKING the community of microorganisms found on the roots of tea plants could make your favourite brew even tastier.

Just as the bacteria that live in our guts can influence our health, microbes that dwell on plant roots play a role in how vegetation absorbs nutrients from the soil.

To investigate if the microbes affect the flavour and nutritional content of tea, Zhenbiao Yang at the University of California, Riverside, and his colleagues collected and analysed tea plants (*Camellia sinensis*) grown in Fujian province, China. They found that certain soil microbes were linked to greater nitrogen uptake, which boosted the production of a chemical called theanine in the plant's roots, and hence levels in the leaves, especially in a variety called Rougui.

Theanine adds a rich, umami taste to brews and how much of it is present is considered a key marker of a tea's quality. It also has antioxidant and anti-inflammatory properties and can counter the stimulating effect of caffeine, says Yang.

For the next stage of their study, the researchers extracted 21 of the most beneficial microbes for theanine from soil to produce a bespoke microbial community, the composition of which was extremely similar to that found naturally around Rougui.

ARTUR SZYMCZYK/ALAMY

The growth of a tea crop is influenced by organisms that reside in the soil

Applying this mix to the roots of other tea plant varieties enhanced theanine levels, even in those grown in nitrogen-poor soils (*Current Biology*, doi.org/mgzz). "Not only are there greater health benefits, it also improves the sweet and savoury flavour of tea," says Yang.

The team hopes bespoke microbial communities will be used to tailor tea and improve the nutritional value of other plants, such as rice.

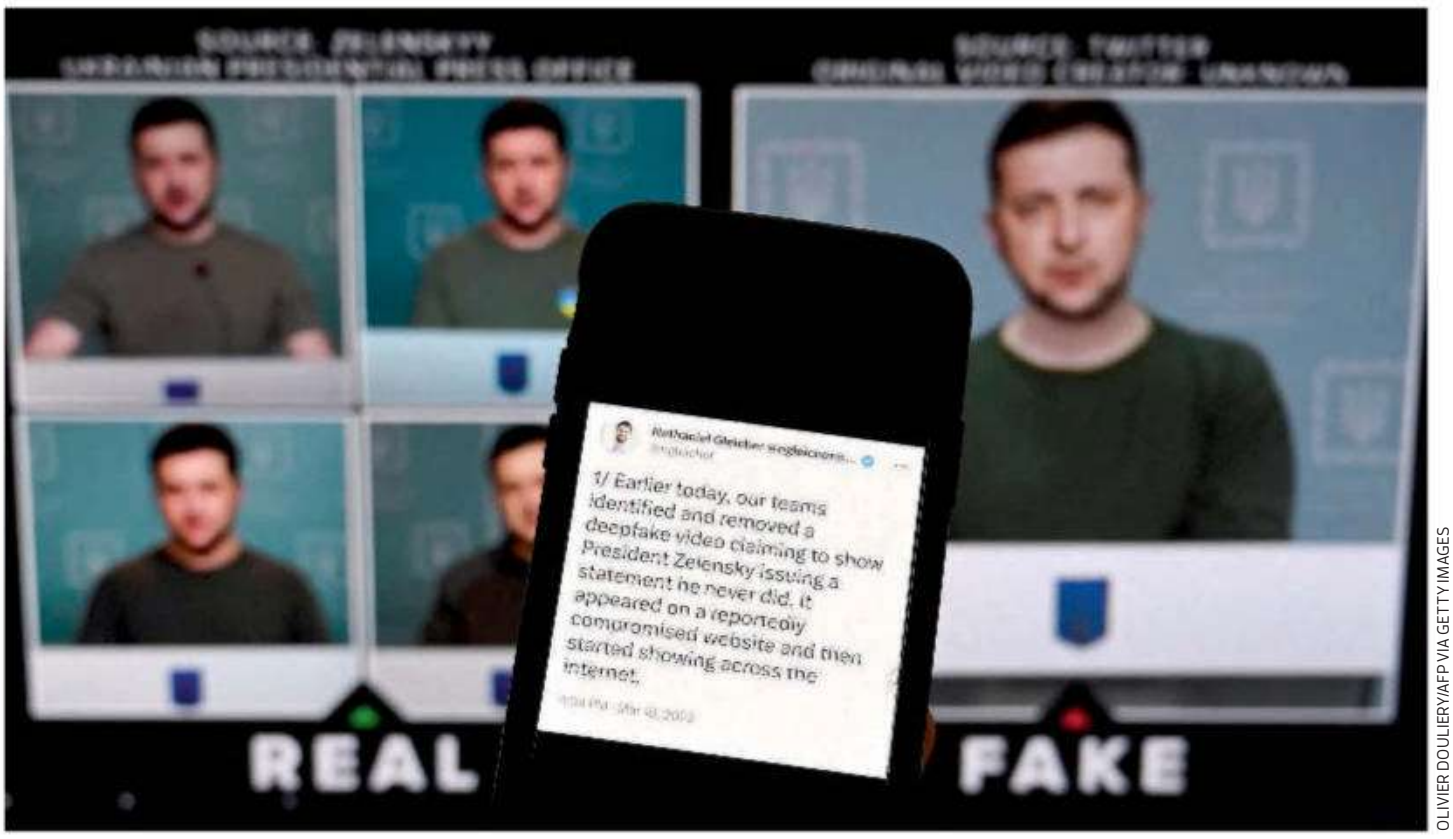
"Increasing the efficiency of nitrogen absorption can also reduce our reliance on fertilisers, which could have huge implications for the future of agriculture too," says Yang.

Chen Ly

Technology

Can deepfakes be stopped?

AI-manipulated videos are used to harass people, scam money and influence elections. Is it too late to control them, asks **Jeremy Hsu**


SOURCE: ZELENSKYY
SOURCE: TWITTER
1/ Earlier today, our teams identified and removed a deepfake video claiming to show President Zelensky issuing a statement he never did. It appeared on a reportedly compromised website and then started showing across the internet.
REAL
FAKE

OLIVIER DOULIERY/AFP VIA GETTY IMAGES

A deepfake of Ukrainian president Volodymyr Zelenskyy went viral in 2022

SINGER-SONGWRITER and billionaire Taylor Swift shares something in common with a growing number of non-celebrities: the appalling experience of featuring in fake sexual images made by strangers using artificial intelligence.

Barely a week after explicit AI-generated images of Swift went viral online last month, more AI-manipulated images and videos appeared that falsely portrayed her expressing support for US presidential candidate Donald Trump. These incidents were preceded by a scam campaign that cloned the voices of Swift and other celebrities and used lip-syncing AI tools to depict them promoting a fake prize giveaway.

Swift's experience reflects the full range of troubling trends involving AI-generated images, audio and video called deepfakes. Now that they are trivially easy for anyone to create at little to no cost, is it too late to stop their spread?

Trouble, trouble, trouble

AI tools have already fuelled the rise of non-consensual deepfake pornography and financial scams that have duped people and corporations out of millions. Deepfakes are a growing threat to elections through misinformation and disinformation, too. "It is something of real concern that is happening now and is going to get worse fast," says Siwei Lyu at the University at Buffalo in New York.

The first wave of deepfakes gained traction with the development of generative adversarial networks in 2014, a technique that pits AI models against each other, in this case to gradually improve the realism of fake images. Yet this generation of deepfake technology was time-intensive and required creators to have technical expertise in AI. Lyu says that making a 30-second video typically needed weeks of digital post-processing work and large amounts of computing power, while still falling short on realism.

But the rapid commercialisation of newer AI technologies in the past two years has made deepfakes easy to churn out. Anyone who can write a text prompt can create AI-generated images in seconds using products such as Midjourney, DALL-E made by OpenAI, and Stable Diffusion from Stability AI. Other tools let users clone a voice by simply uploading or recording an audio sample. And while some AI services have implemented safeguards against generating certain content – for example, an OpenAI spokesperson says their tools deny requests that ask for a public figure by name or for explicit content – many haven't.

95,000
Number of deepfakes online in 2023

550%
Increase in number of deepfakes between 2019 and 2023

98%
Proportion of deepfake videos that are pornographic

A study last year by Home Security Heroes, a team of online security experts, found there were more than 95,000 deepfakes online in 2023, up 550 per cent since 2019. It also revealed that 98 per cent of deepfake videos were pornographic, with 99 per cent using a woman's likeness.

The pornographic Taylor Swift deepfakes were created by an anonymous group on the internet forum 4Chan in an effort to bypass safeguards on Microsoft Designer, a mainstream AI tool (Microsoft has since fixed the exploited vulnerabilities). "The [4Chan] community is really desensitised to the impact that this has on real humans," says Cristina López G. at social media intelligence firm Graphika. She and Santiago Lakatos, also at Graphika, found that these deepfakes then spread to social media platforms Telegram and X (formerly Twitter) in under two weeks. One X post racked up more than 45 million views before the user's account was suspended. In a statement, Telegram says the firm "has actively moderated harmful content on our platform, including illegal pornography" and has "removed every group sharing this illegal pornography that we know of".

Not all non-consensual deepfakes involve celebrities. Teachers and school-age girls have also been targeted in New Jersey and Texas in the US, as well as countries including Canada, Australia, Spain and Brazil. "It's definitely being used to target women specifically and to

intimidate, to threaten," says Emmie Hine at the University of Bologna in Italy. "It's the same idea as revenge porn, but now you don't even need actual intimate photos – you can just make them up."

Deepfakes are also complicating elections. Last month, a robocall campaign used audio deepfakes of US president Joe Biden's voice to discourage voting in New Hampshire. The US Federal Communications Commission

"I'm afraid the ship has sailed on deepfakes, and it's not just a ship – it's a large flotilla, an armada"

then ruled that any such calls made with AI-generated voices are illegal. Deepfakes also targeted a candidate in Chicago's mayoral election in February 2023 as well as a politician in New York City last month.

Just a single deepfake could disrupt national politics. "Even if it's only once that you're on the eve of the election in the United States and some deepfake of Joe Biden comes out... that could have a huge impact," says Sarah Kreps at Cornell University in New York.

One such event may have already occurred during the parliamentary election in Slovakia in September 2023. An audio deepfake falsely depicting a party leader as planning to rig the election was posted to Facebook just before voters went to the polls. A rival party won the election.

Deepfakes could also be a national security threat if used to extract information or spur actions from government staffers or military personnel, says Kreps. "This technology is so prevalent now that we almost can't scope the number of scenarios that is possible," she says.

Troublingly, deepfakes of the political, pornographic or scam variety may become even more commonplace (see "Scammers use stolen voices", below). "I'm afraid the ship has sailed, and it's not just a ship – it's a large flotilla, an armada," says V.S. Subrahmanian at Northwestern University in Illinois.

Reining it in

Solutions to the problem so far have been overly narrow. The European Union's Digital Services Act requires tech platforms to identify and label AI-generated content. The US is developing similar standards. And the tech industry has embraced a standard called C2PA that would encode digital content with information about where it came from and who created it. Earlier this month, Meta announced that it would flag AI-generated images on its social media platforms, while Google said it would integrate a C2PA watermarking system for its generative AI tools, as did OpenAI.

Watermarking efforts from the big tech firms can be helpful, but they don't stop malicious actors from using open-source AI tools, says Hany Farid at the University of California, Berkeley. They also fail to address violations of privacy and consent for those affected by deepfake pornography – especially when the aim is to harass and intimidate, says Gili Vidan at Cornell University. "The focus on... whether the media was or wasn't manipulated using AI is almost irrelevant to the actual issue," she says.

JIM LO SCALZO/EPA-EFE/SHUTTERSTOCK

VALERIE MACON/AFP VIA GETTY IMAGES

Recent deepfakes used the AI-generated voices of Joe Biden and Taylor Swift

At least six US states and several countries have made it illegal to create or distribute harmful deepfakes, and the US is considering a similar federal rule. But a recent study showed that places where sharing or viewing deepfake pornography is outlawed, such as Australia and South Korea, have some of the highest prevalence of creating, sharing or viewing such images and video. That is why tech platforms may have the most power and responsibility to stem the deepfake tide.

In a 13 February blog post, Microsoft president Brad Smith wrote that the firm aims to protect freedom of expression without shielding distributors of non-consensual pornography. Google, Midjourney, Stability AI, X and 4Chan didn't respond to a request for comment. Meta shared its existing policies on deepfakes, which its own Oversight Board this month called "incoherent".

Sophie Maddocks at the University of Pennsylvania says it is time for a societal reckoning over sexualised deepfakes – whether of Swift or anyone else. "The solutions aren't necessarily rocket science. They just require us to reorient our values around the bodily autonomy of everybody and the privacy of everybody, including women." ▮

Scammers use stolen voices

Deepfakes are supercharging traditional scams. In 2023, the US Federal Trade Commission warned the public about "grandparent scams" that use the cloned voices of family members to trick people into sending money to help a loved one in a fake emergency.

Ambitious scammers have aimed for even more lucrative payouts by targeting businesses with the help of deepfaked executives. One of the first such incidents reported occurred in 2019 and involved the CEO of a UK-based energy company being tricked by deepfake audio of his boss. The CEO ultimately sent $243,000 to the scammer's bank account.

Such scams have become more elaborate in recent years. This month, Hong Kong officials revealed that an employee of a multinational company was fooled into transferring more than $25 million in company funds. The scammers used deepfakes to create a Zoom call featuring a convincing video of the company's chief financial officer along with other employees.

Evolution

Humour may originate in the way great apes love to tease

Chen Ly

BONOBOS, orangutans, gorillas and chimpanzees all poke, tickle and even steal from their peers as a form of playful teasing. Understanding the mischievous behaviour of these apes could help us work out the origins of the human sense of humour.

Previous studies have found that chimpanzees may engage in agonistic teasing, or harassment, to reinforce their hierarchical positions. But when the right balance of enjoyment and aggression is struck, teasing can also be a form of play and amusement,

18

Number of types of playful teasing apes engaged in

says Isabelle Laumer at the Max Planck Institute of Animal Behavior in Germany.

"So far, the playful side of teasing has not yet been systematically studied," she says. "So our goal was to identify and create a criteria for playful teasing in apes."

To do that, Laumer and her colleagues collected videos of five species of great ape: bonobos (*Pan paniscus*), Sumatran orangutans (*Pongo abelii*), western and eastern gorillas (*Gorilla gorilla* and *Gorilla beringei*) and chimpanzees (*Pan troglodytes*). There were a total of 34 apes, all housed in zoos.

After examining 75 hours of video footage, the team documented 504 social interactions between individuals. Of those, 142 were classified as examples of playful teasing, consisting of 18 behaviours, including poking, hitting, pulling on hair, hindering movement and stealing.

"Teasing is characterised by a provocative element," says Laumer. "It's usually coming from the teaser and often one-sided, with lots of repetition."

The researchers found that the teaser tended to look at their target's face straight after an action, which suggests that a response was anticipated. If there wasn't any reaction, the teaser would usually escalate the teasing, for example by poking them even more (*Proceedings of the Royal Society B*, doi.org/mgv5).

One of the most important signs that the teasing was playful, instead of being antagonistic, was that it typically happened in a calm, comfortable setting. "The individuals tended to be relaxed during the interaction," says Laumer.

Cases of stealing were considered playful when the object presented no obvious benefit to the teaser or if they lost interest in the object soon after pinching it.

"We find that playful teasing is present in all four great apes," says Laumer. Much like play in general, this behaviour could be useful in building relationships between members of a group and even testing out social boundaries, she says.

Great ape japes

The last common ancestor between humans and the other great apes may well have engaged in playful teasing too, which could have been the forerunner of our fondness for jokes, says Laumer.

"Studying great apes is critical to understanding which features of human cognition and behaviour are shared and likely evolved millions of years ago in a common ancestor," says Christopher Krupenye at Johns Hopkins University in Maryland. "This study provides exciting evidence that all apes seem to engage in playful teasing behaviour and also charts a path for future research in other species." ▮

ZOONAR GMBH/ALAMY

Western gorillas can be playful and enjoy teasing each other

Solar system

Carbon dioxide gas glimpsed in Callisto's thin atmosphere

Chen Ly

ASTRONOMERS have spotted gaseous carbon dioxide across the atmosphere of Jupiter's second-largest moon, Callisto, hinting that it might have a much more complex carbon cycle than we thought. On Earth, the carbon cycle helps to sustain a stable climate.

Callisto is one of the solar system's oldest objects, having formed some 4.5 billion years ago around Jupiter. Space probes have revealed that the moon is mostly covered with ice, mixed with large amounts of solid CO_2. In 1997, the Galileo probe spotted some hints that there may also be gaseous CO_2 in Callisto's thin atmosphere.

Now, Richard Cartwright at Johns Hopkins University in Maryland and his colleagues have confirmed the presence of CO_2 gas on the moon.

The researchers analysed data from the James Webb Space Telescope's near-infrared spectrograph instrument, which disperses light from objects such as moons and planets into a spectrum that tells us about their chemical composition. They found that CO_2 was distributed all around Callisto's atmosphere, with higher concentrations towards the moon's south pole (arXiv, doi.org/mgzn).

One explanation for the presence of CO_2 gas could be that meteor impacts or Jupiter's powerful radiation belt are disturbing the moon's surface, allowing CO_2 to seep out of the crust and into the atmosphere, says Cartwright. Another possibility is that energetic photons are reacting with the solid CO_2 on the surface to produce the gas.

"There's debate whether the CO_2 comes from Callisto's interior or if it is being made on the surface," he says. "The answer is probably both."

"This looks an intriguing study which might indicate a carbon cycle on Callisto," says Andrew Coates at University College London. ▮

Psychedelics

Even tiny LSD doses affect the brain

A measure of consciousness called neural complexity increases with small amounts of the drug

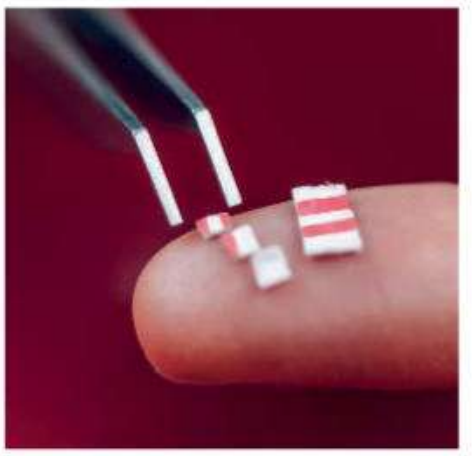
Grace Wade

LOW doses of the psychedelic drug LSD increase complexity in the brain, even when they don't alter consciousness. The finding hints that even small doses of LSD might have therapeutic effects.

Neural complexity is a measure of the amount of information the brain produces, with all repetitive signals removed – that is, the lowest number of unique brain signals over a given period.

Studies have shown that neural complexity correlates with consciousness. This means it decreases when we are asleep or in a coma and increases when we are awake. High doses of psychedelic drugs also boost neural complexity, leading some people to posit that this may be how the drugs exert therapeutic effects in some mental health conditions.

To see if neural complexity changes with small doses of psychedelics, Conor Murray at the University of California, Los Angeles, and his colleagues gave 21 adults either a placebo or



SHUTTERSTOCK/MICROGEN

Microdoses of the psychedelic drug LSD alter brain activity

13 or 26 micrograms of LSD. Doses this small typically don't elicit hallucinatory effects.

The researchers used electroencephalography to measure the electrical activity of participants' brains and assess neural complexity.

They repeated the experiment in two other groups using high doses of methamphetamine and tetrahydrocannabinol (THC), a psychoactive compound in marijuana. At these doses, THC, but not methamphetamine, can influence consciousness.

Only the 26-microgram dose of LSD significantly changed neural complexity, raising it by about 12 per cent above levels seen with the placebo, on average. Questionnaires indicated this dose didn't alter people's state of consciousness, although they reported some effects (*Neuropsychopharmacology*, doi.org/mgv4).

Murray says this challenges the idea that shifts in complexity and consciousness are always correlated, and is supported by the fact that THC altered participants' consciousness without changing their neural complexity.

The microdoses seem to act on the brain in similar ways to higher doses of LSD, says Murray. That may be why people report feeling more creative and connected with others when microdosing the drug. However, clinical trials haven't found that microdosing improves well-being more than a placebo does, making it unclear if these small doses are really beneficial, especially given potential risks. "We really don't know the dangers of repeated low doses, either on the brain or other organs," says Murray.

"We really don't know the dangers of repeated low doses, either on the brain or other organs"

The result "suggests that [neural complexity] is not a mere arousal effect, as it didn't increase with methamphetamine, nor a generic 'high', as it didn't increase with THC", says Robin Carhart-Harris at the University of California, San Francisco. But he disagrees with the researchers' claim that low doses of LSD don't influence consciousness, since participants reported feeling the drug. "I think we need better scales to pick up on psychedelic effects," he says. ▮

Zoology

Flea toad may be the world's smallest vertebrate

A TINY Brazilian frog about the size of a pea may threaten the current record-holder for the world's smallest vertebrate.

The flea toad *Brachycephalus pulex*, which is actually a frog species, was first described by scientists in 2011. Shortly after, Mirco Solé at the State University of Santa Cruz in Brazil wondered if the species could be the smallest amphibian yet discovered.

But only a handful of specimens had been collected from the frogs' only known habitat on two forested hilltops in southern Bahia, Brazil. And their gonads hadn't been examined, which is necessary to confirm if they are adults.

Solé and his colleagues measured the body lengths of 46 flea toads, verifying the maturity and sex by examining gonads and checking for the presence of vocal slits in their throats, something only males have (*Zoologica Scripta*, doi.org/mgv2).

They found adult *B. pulex* males average a touch over 7 millimetres long, slightly smaller than the females. This makes them smaller than the males of *Paedophryne amauensis*, a frog from Papua New Guinea that was, until now, considered both the smallest amphibian and smallest vertebrate.

RENATO GAIGA

A flea toad perches on a Brazilian real (the coin's diameter is 27 millimetres)

"It's absolutely clear," says Mark Scherz at the Natural History Museum of Denmark in Copenhagen. "These really are potentially the smallest extant frogs in the world, which is astonishing."

It isn't just the average size that is surprising, but how small these adult flea toads can be compared with other mini frogs. The smallest male specimen in the study was "6.45 millimetres [long], which is 30 per cent smaller than any adult male frog I have ever seen", says Scherz. "It's almost 1 millimetre smaller than the next smallest frog."

At such small scales, frogs develop strange anatomical quirks, such as losing toes or having such underdeveloped ears that they can't hear their own suitors' songs. Some species can hardly jump because their balance organs are so wee.

Yet there might be even smaller vertebrates still undiscovered, says Solé. ▮

Jake Buehler

Cosmology

Newborn black holes spew gas so hard they almost stop spinning

Leah Crane

MOST black holes may spin far more slowly than expected. When black holes form from collapsing stars, they emit powerful jets of energy, and these jets slow down the black holes' spin to nearly nothing within minutes.

The spin of a newborn black hole is governed by two competing phenomena. When fast-moving material in its orbit falls in, the black hole takes in energy and its rotation speeds up. But that same consumption causes a huge jet to blast away from the black hole for a few minutes, which leaks away energy and slows it down.

Now, Jonatan Jacquemin-Ide at Northwestern University in Illinois and his colleagues have used a series of simulations to examine how these two processes interact and where that leaves black holes once their formation is complete.

They found that collapsars – the name given to black holes left behind after a star collapses, which make up most of the black holes in the cosmos – should barely be spinning at all.

"Before, most works didn't really consider the spin-down through the jet, so [a simulated black hole] would just eat and eat and eat the gas and that would spin it up more and more, so you would expect a lot of black holes to be maximally spinning," says Jacquemin-Ide.

"You have this event that lasts maybe 100 seconds, but it can change the spin of the black hole"

Astronomers measure black hole rotation using a parameter called the dimensionless spin, or a. When a equals 0, the black hole isn't spinning at all. When a equals 1, it is spinning at the maximum possible rate for an object with its mass. The researchers found that just after their births, collapsars should rotate with a dimensionless spin of about 0.2 or lower (*The Astrophysical Journal*, doi.org/mgvn).

"It shows just how powerful the jets can be," says Jacquemin-Ide. "What surprised me most is that this happens very fast. You have this event that lasts maybe 100 seconds, but it can absolutely change the spin of the black hole."

This matches what astronomers have observed through gravitational waves, which are ripples in space-time that occur as a result of the motion of massive objects. The Laser Interferometer Gravitational-Wave Observatory (LIGO) has felt the waves from nearly 100 mergers between pairs of black holes, and measurements indicate that the dimensionless spins of the black holes before they slam together tend to be around 0.2.

"With gravitational waves, we observe black holes at a very specific instance in their lives, right at the end, and they spend billions of years before that doing other stuff," says Katerina Chatziioannou at the California Institute of Technology. "This work adds one more piece to the puzzle of their lifetimes."

It could also help us discern different types of black hole. "There are other ways than stellar collapse to make black holes – perhaps more rare, but they are there," says Chatziioannou. "One of the big issues for us is how to tell them apart and this might be a way to separate them."

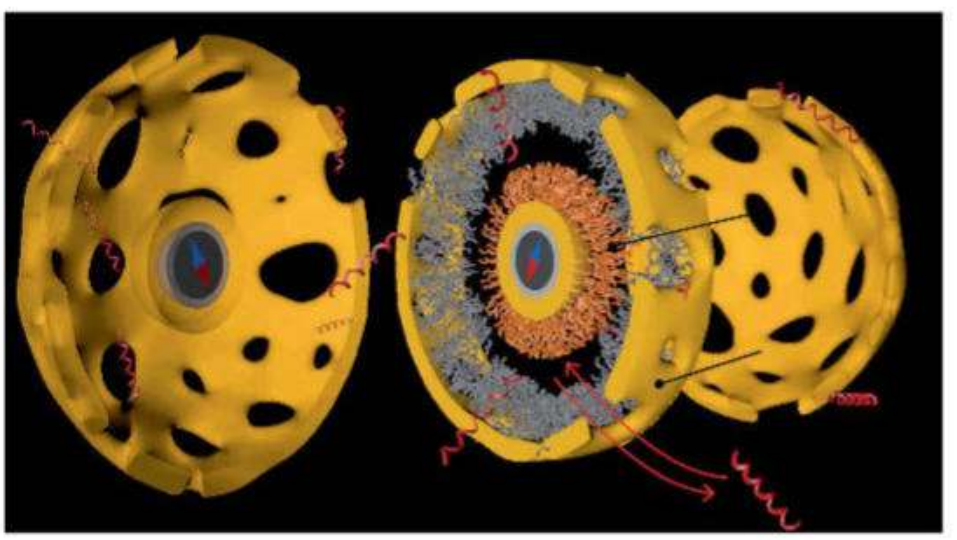
Black holes that have undergone mergers tend to have higher spins, closer to 0.7, than the "pristine" ones the researchers considered here, so measuring the spin of a black hole could help us piece together its past. ▮

Biotechnology

Nanobot uses a DNA clutch to engage its engine

A NANOSCALE robot with a clutch can engage or disengage its engine, allowing for more precise control. It could be used to kill harmful cells.

Tiny clutches exist in nature – for example, the bacterium *Bacillus subtilis* moves using hair-like structures called flagella, each attached to a rotating molecular engine. "Once [the bacteria] arrive at their target area, they will take a rest," says Jinwoo Cheon at Yonsei University in Seoul, South Korea. "They use a molecular clutch such that the engine is still on, but there is no force transmission into the flagella, so they are saving energy."



JINWOO CHEON ET AL. (2024)

The robot has a gold and iron engine that can be attached to its gold cage by a DNA clutch

Now, Cheon and his colleagues have created their own version – a nanomachine powered by magnetic fields, with a clutch made from DNA. The motor is a nanoparticle made from gold and iron oxide that rotates in a magnetic field and is surrounded by a spherical gold cage. The cage is about 200 nanometres across, similar in size to a typical virus (*Nature Nanotechnology*, doi.org/mgvw).

The researchers attached single strands of DNA to the inside of the cage and the outside of the nanoparticle motor. When the engine is triggered by adding a specific molecule, the DNA strands on both surfaces fuse together and the nanoparticle connects to the cage, engaging the clutch.

Cheon and his colleagues tested the engine with the clutch engaged and found that, when rotating, it could apply a force of about 15 piconewtons. In experiments with cancerous human bone cells, this was enough to mechanically activate certain cell receptors, meaning that the robot could be used to make cells divide or die. ▮

Alex Wilkins

Food science

Beef-rice hybrid is more sustainable

SOON you could sit down to a meal of beef and rice where the ingredients are a lab-fused hybrid.

Aiming to create a "new complete meal", Jinkee Hong from Yonsei University in Seoul, South Korea, and his colleagues coated rice grains with fish gelatin so cultured cow muscle cells could stick to them. They then put the rice in a medium to encourage the cow cells to multiply in the grains.

The resulting beef-rice hybrid can be boiled or steamed. Hong says its texture is harder and less sticky than regular rice, and it has a nutty taste. It contains 7 per cent more protein and 8 per cent more fat than normal rice and making it releases about 6 kilograms of carbon dioxide for every 100 grams of protein, while beef releases about 50 kg (*Matter*, doi.org/mgxj). **James Woodford**

LAFFRANCHI ET AL. (CC-BY 4.0)

Mind

Our interpretation of emojis can vary

THINK twice before you reply to a message using just an emoji – how people understand them varies.

Ruth Filik at the University of Nottingham, UK, and her team surveyed 253 people in China and 270 in the UK aged between 18 and 84. They found that women were more likely than men to match one of 24 emojis to the emotion that the researchers had attributed to the small images (happy, disgusted, fearful, sad, surprised or angry). And younger people matched up the emojis more accurately than older counterparts (*PLoS One*, doi.org/mgxk).

British participants did better than Chinese ones, which may be due to the groups using emojis in different ways. For example, people in China seldom use the happy emoji for happiness, instead, they use it for sarcasm, say the researchers. **Chen Ly**

Archaeology

Ancients may have taken beloved pets to the grave

LATE Iron Age people in northern Italy were sometimes buried with their dogs or horses – possibly just because they loved them.

Marco Milella at the University of Bern in Switzerland and his colleagues revisited bones excavated from the 2200-year-old Seminario Vescovile burial ground just east of Verona, where the Cenomani people lived in metal-making communities before and during the Roman conquest.

Most of the 161 graves found at the site contained just the remains of a person, but 16 also included animals, either whole or in parts. Of those, 12 were pork or beef products, apparently meant as food offerings to the deceased, says team member Zita Laffranchi, also at the University of Bern.

The other four people were buried with dogs or horses or both of these animals, which weren't used for food in that population. They included a middle-aged man with a small dog, a young man with parts of a horse, a 9-month-old baby girl side-by-side with a dog (pictured above) and a middle-aged woman with a pony laid on top of her and a dog's head above her own.

"At first the excavators were surprised to find human legs under a horse, and the first idea was: we have a horse rider here, we have a warrior," says Laffranchi. But the woman had been buried without weapons, suggesting her relationship with the 1.3-metre-tall pony wasn't related to warfare (*PLoS One*, doi.org/mgxh).

The findings point to the possibility that people from ancient populations felt so connected with their animals that their loved ones chose to bury them together, say the researchers. Christa Lesté-Lasserre

Really brief

TRACY FOWLER/MBI/ALAMY

School uniform hampers activity

Wearing a school uniform has been linked to children getting insufficient exercise, expecially if you are a girl. The finding comes from data on the physical activity levels of more than 1 million children aged 5 to 17 years from 135 countries and territories (*Journal of Sport and Health Science*, doi.org/mgxp).

Half of the Amazon is under threat

Satellite data suggests that 47 per cent of the Amazon rainforest will experience at least one environmental stressor in the next 25 years that could push some ecosystems past a climate tipping point. The potential for a wider collapse of the forest remains uncertain (*Nature*, doi.org/mgxr).

Sperm perked up by ultrasound burst

Ultrasound can get sluggish sperm moving. Sperm that don't move properly are a cause of infertility because it is harder for them to reach an egg. Immobile ones became active after 20 seconds of exposure to ultrasound waves in a lab experiment that may boost fertility treatments (*Science Advances*, doi.org/mgxt).

Perpetual lunacy

The extraordinary new **C1 Moonphase** from Christopher Ward. A watch that tracks the moon for 128 years – without missing a beat. With an aventurine glass dial infused with copper oxide to represent the night sky. And a 3D 'moon' sculpted from Globolight© – a luminous ceramic – that precisely follows the real moon's journey across the sky. A watch this advanced can cost up to £45,000. But the C1 Moonphase starts from less than £2,000. As someone once said, you don't have to be mad to work here...

Do your research.

Christopher Ward

christopherward.com

SCAN ME

Views

The columnist
Annalee Newitz on strange Taylor Swift "psy op" theories p22

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Culture columnist
Bethan Ackerley finds *Constellation* is a bumpy ride p30

Comment

A toxic debate

Growing alarm over "ultra-processed food" is anti-science and misplaced. Stick to the evidence, says biologist **Jenny Chapman**

THIS morning, I spread a "mechanical mixture" made through "the ingenuity of depraved human genius" on my toast. I'm sure some of you are thinking I must be in the camp that enjoys a certain divisive, brown savoury condiment that is common in the UK (and yes, I do love Marmite!). However, it was simply an emulsion of vegetable oil and water. A processed, more sustainable and healthier alternative to an animal product. In other words, it was margarine and those alarmist words were uttered about it in the late 1800s by a US politician a decade or so after it was first sold.

Anxiety about new foods and how they are produced continues today. Public discourse is full of overhyped concerns that "ultra-processed foods" or "UPFs" are demonically unhealthy. But how and where what we eat is made isn't a proxy for how safe or nutritious it is. Being wrapped in plastic, having more than five ingredients or containing something you can't pronounce doesn't tell you if it is good for you. It just tells you where it was (probably) made – in a factory.

The term "ultra-processed" was first used in 2009 by Carlos Monteiro, a nutritionist. In a 2017 paper, he said he was worried that social life was being "weakened" in his native Brazil – that the shared experience of cooking was being increasingly lost and people weren't eating together. He was also seeing rising rates of diabetes and obesity. Keen to identify the root cause of these perceived issues, he homed in on food not made at home, but in factories.

ELAINE KNOX

To identify these, he developed a sociopolitical classification scheme. At five paragraphs long, his definition of UPFs considers everything from packaging, branding and marketing to types of ingredients, highlighting those for which there are "no domestic equivalents". It is subjective, using phrases like "many" and "some", but on the whole it does a fantastic job of telling you if a food was made in a small kitchen or not. Homemade potato wedges or a chocolate cake wouldn't be classed as UPFs, but store-bought tofu or prepared salad would be.

Herein lies the problem: the UPF categorisation was never designed to group foods on the basis of nutrition. Monteiro states this explicitly, right in the title of his seminal paper: "The issue is not food, nor nutrients, so much as processing". Despite this, many well-meaning nutrition scientists have attempted to use his framework in studies looking at links between diet and health.

The results are, understandably, bewildering, and to be expected when the category includes everything from salty, oily potato crisps to fibre-rich soya mince.

One particular category I have been researching is in a fierce spotlight: plant-based meats. Just like pork sausages and chicken nuggets, plant-based alternatives are made in factories, so are considered UPFs. But unlike their meat counterparts, they don't require antibiotics or hormones during production, don't increase the risk of zoonotic diseases evolving, require up to 96 per cent less land, have carbon emissions up to 98 per cent lower, need up to 99 per cent less water and result in 100 per cent fewer animals dying.

And side by side, they are almost always healthier than the processed animal meat products they replace, especially on fat and fibre content. Just compare the labels on the packets next time you are in the supermarket.

Many loud voices are raising concerns, suggesting that all UPFs, and in particular plant-based meats, are "unnatural", "fake" and "full of chemicals". We are seeing history repeat itself, and a fear of new foods being invoked all over again. But the science is as clear as the discourse is unclear: diets rich in plant-based fare are better for both people and the planet, factory or no factory.

Jenny Chapman's report on plant-based meat issues was published by the Churchill Fellowship

This changes everything

When fandom becomes politics

The conspiracy theory that Taylor Swift is a "psy op" is a symptom of the profound confusion online media is creating, writes **Annalee Newitz**

Annalee Newitz is a science journalist and author. Their latest novel is *The Terraformers* and they are the co-host of the Hugo-winning podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is **techsploitation.com**

Annalee's week

What I'm reading
Means of Control
by Byron Tau, a history of high-tech surveillance in the US.

What I'm watching
Blue Eye Samurai,
an animated series full of sword fighting and revenge.

What I'm working on
A novella about robots who make noodles.

This column appears monthly. Up next week: Alex Wilkins

AS I wrote this, helicopters flew overhead, circling the city where I live. Even though San Francisco lost the Super Bowl against Kansas City, fans were partying – and police were on high alert. For good reason too, as the tragic mass shooting in Kansas City during post-game celebrations attests. In the US, big events often end in horrifying gun violence.

There was an added element of tension in sports fandom this year. Taylor Swift is dating Travis Kelce, who plays for Kansas City – and that means her fans were in the audience at the Super Bowl, basking in her glow. But the issue isn't whether Swifties are outshining Kansas City fans. It is political.

For the past few months, right-wing influencers online and on Fox News have made increasingly wild claims about how Swift is a psychological operation, or "psy op", created by the US military. In these conspiracy theories, the idea is that Swift is using her celebrity to broadcast hidden messages about how people in the US should vote for Democrats. Before the game started, presidential hopeful Donald Trump heightened the chaos by declaring that Swift might endorse President Biden for a second term, and called her "disloyal".

The pop megastar has rarely spoken about politics, but she did quietly endorse Joe Biden in the 2020 presidential election – and in the documentary *Miss Americana*, she voiced support for LGBT+ people. She has also urged her followers to vote, regardless of who they back.

Meanwhile, her boyfriend Kelce appeared in a public service ad about getting vaccinated against covid-19 and flu. These faint whiffs of liberalism and pro-science beliefs have earned the couple a spot at the centre of reactionary paranoia.

Conspiracy shills have accused Swift of rigging the Super Bowl and the 2024 presidential election, while secretly working as an asset for the Pentagon (hilariously, the Pentagon actually had to issue a formal denial).

At the same time, artificial intelligence-generated deepfakes showing Swift in pornographic scenarios have been spreading on social media (see page 14). The images created such an uproar that the US Congress immediately proposed a bill

"At this point, Taylor Swift might as well be a politician. She is getting the same abuse as women who run for office"

to stop non-consensual sexual depictions of real people created by AI. Executives at Meta have also promised that AI images will soon have warning labels on Facebook, Threads and Instagram. At this point, Swift might as well be a politician, given she is getting the same online abuse usually heaped on women running for office.

However, the subtext here isn't that she is a clandestine political asset, it is that the US has entered a dangerous cultural moment, where some of its citizens cannot distinguish between entertainment and politics. Fandom, after all, can look very much like a social movement. From a distance, it is easy to confuse thousands of screaming Swifties with an insurrectionary force.

This is especially true right now, when online media has nuked the border between pop culture and political information. Twenty years ago, fandom existed in its own spaces – you could go to a concert, a game or a science fiction convention and nobody would start screaming about psy ops. Newspapers and magazines had separate sections for political news and sports news.

With fandom absorbed into social media communities, however, our feeds spew politics and entertainment information at us indiscriminately. To grab our attention in this information fire hose, political operatives are more likely to use the language of pop culture. As a result, people just looking for a happy musical distraction can't find it. The right has turned Swift into a psy op that its followers are supposed to avoid.

Sadly, the US isn't the only place where this kind of thing is happening. In 2020, the Chinese government blocked its citizens' access to Archive of Our Own, an online repository of free "fanfiction" – stories written by fans set in the universes of their favourite shows, movies and sports teams. Why? Fans in China were fighting online over whether it was OK to represent a popular idol, Xiao Zhan, in fictional stories with LGBT+ themes. After the crackdown, an arena of public fun and creativity has been lost.

The Swift psy op discourse and fanfic censorship are examples of a profound cultural confusion that has impoverished our art and our politics. And, perhaps, it is a sign of something even more dangerous. Walter Benjamin, a philosopher who witnessed Adolf Hitler's rise to power in Germany, warned that fascism thrives in an environment where politics is indistinguishable from aesthetics. Taylor Swift isn't the psy op that endangers us. Instead, it is the political actors who use her as bait. ▮

Events

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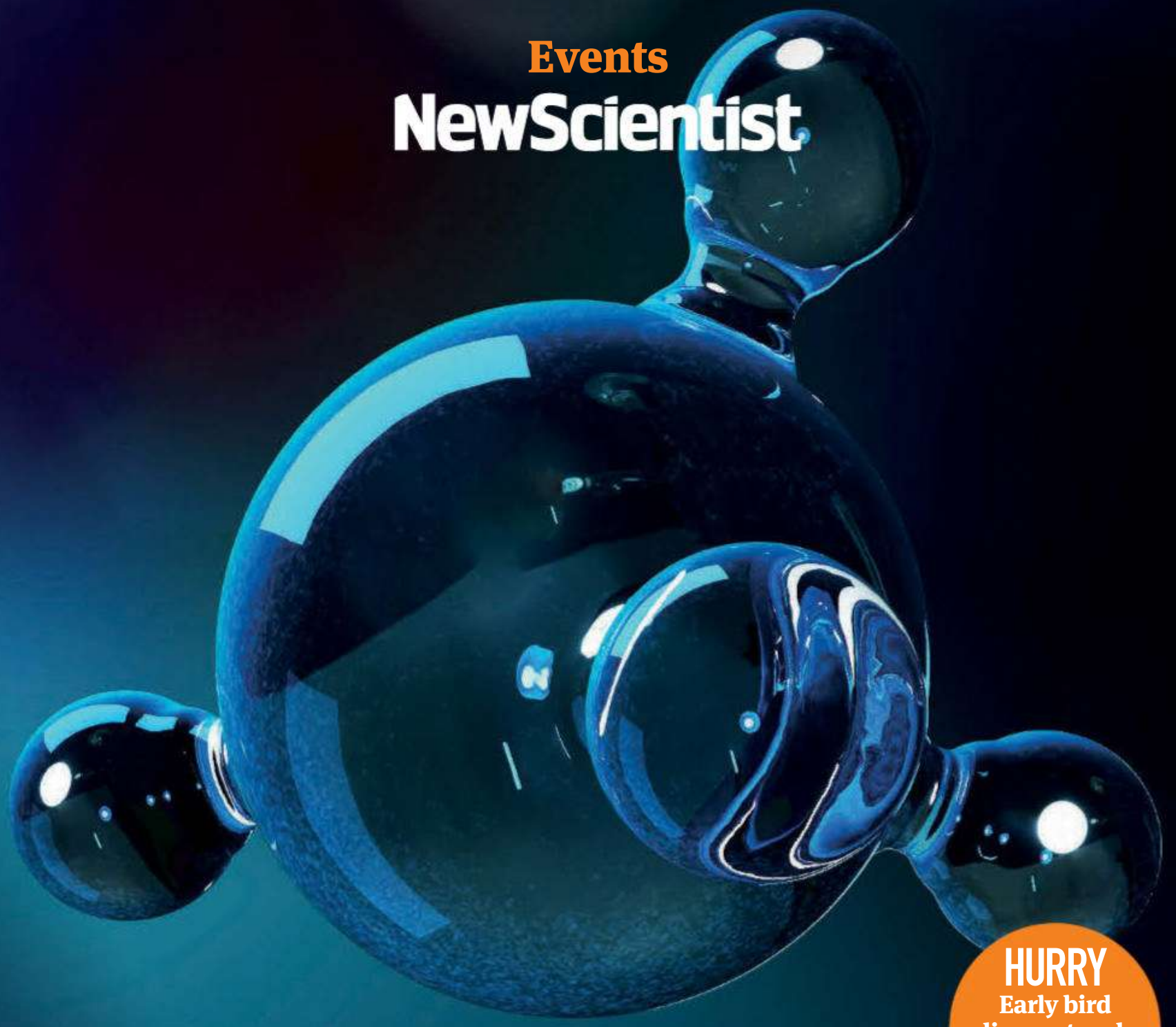

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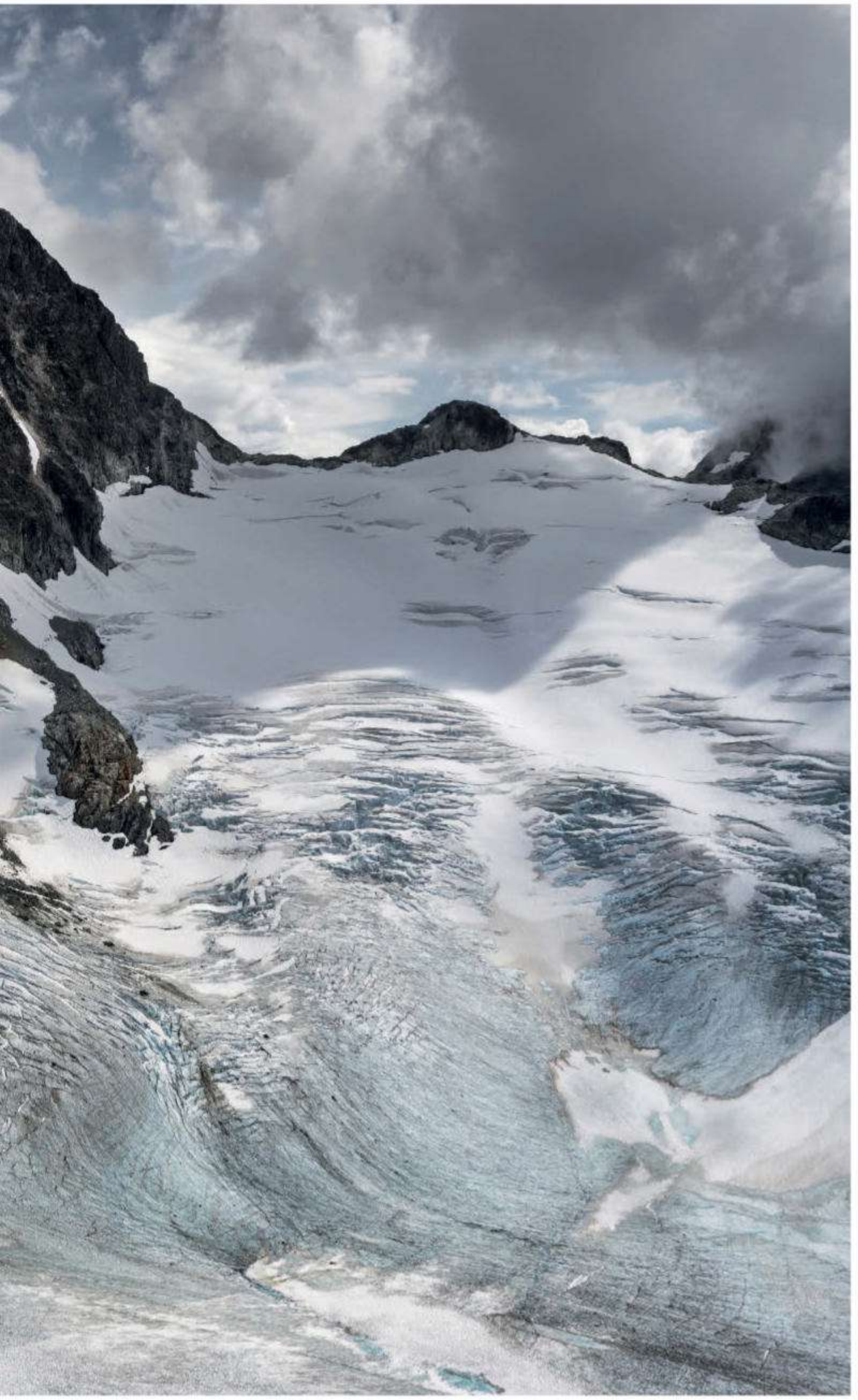

End of the ice

Photographer Edward Burtynsky
Flowers Gallery, London

THIS frigid scene in the Coast mountains in British Columbia, Canada, is a sight to behold – but enjoy it while you can as it may not be like this for much longer.

When snow falls in places like this, it becomes compacted into thick ice that flows over the land and forms a glacier, creating giant reservoirs of water that sustain life when melting occurs. These are an ancient and vital resource.

The process of glaciation has been happening throughout most of Earth's history. But many of these icy relics are at risk of being lost, says photographer and artist Edward Burtynsky. That is the message behind this photo, on display in the *New Works* exhibition at the Flowers Gallery in London from 28 February until 6 April.

Burtynsky took the shot from a helicopter and was shocked to see that the glaciers had receded dramatically compared with 20 years ago, when he last visited. The glaciers in this range date as far back as 150,000 years, but they are shrinking rapidly because of warming as a result of human activity.

"When that's gone, it's gone, and the whole ecosystem and the whole life system will change forever," says Burtynsky. His images are designed to serve as a reminder of what has been lost, he says. *New Works* also focuses on soil erosion in Turkey and the impact of coal mining on Australia.

Burtynsky is currently displaying in another exhibition in London, *Extraction/Abstraction*. This also explores the human impact on the planet and is at the Saatchi Gallery until 6 May.

Gege Li

Editor's pick

Personal glucose monitor did the trick for me

3 February, p 40

From Erik Foxcroft, St Albans, Hertfordshire, UK

Like Clare Wilson, I too tried a blood glucose monitor from ZOE, partly out of curiosity and partly for potential health benefits. I wasn't too concerned about blood glucose "spikes". It was the resulting "dips" I wanted to eliminate. What I had surmised were that periods of low glucose, which felt like having a hangover, made me lethargic and less clear-headed until I ate again.

The monitor confirmed my suspicion and allowed me to identify the – sometimes surprising – foods with the worst effects. I doubt I could have done this with careful experimentation with the same speed or with such ease.

Is everything in the cosmos made of shapes?

10 February, p 32

From Trevor Jones, Sheringham, Norfolk, UK

Reading about the use of abstract geometry in the search for a theory of everything, I was intrigued by Renate Loll's take: causal dynamical triangulation, rooted in the simple geometry of triangles and tetrahedrons.

This reminds me of one of geometry's great treasures, as Johannes Kepler put it: the golden ratio. So many natural forms embrace this ratio in growth and shape, from microcosm to macrocosm. Perhaps this extends to galaxies and space-time?

Bennu may just be a chip off the old block

10 February, p 8

From Andrew Taubman, Sydney, Australia

Given that the asteroid Bennu is in roughly the same orbit as we are, is it possible that the "small, ocean-covered world with conditions favourable for life to emerge" that the rock came from is Earth? Maybe created in the same impact that tore the moon from our planet?

On the use of exercise therapy for long covid

17 February, p 14

From Charles Shepherd, honorary medical adviser, ME Association; Sonya Chowdhury, CEO of Action for ME; and Nicola Baker at the University of Liverpool, UK

You report on the use of exercise for long covid. This condition and myalgic encephalomyelitis/chronic fatigue syndrome (ME/CFS) have some important clinical and pathological overlaps and a significant proportion of people with long covid also meet diagnostic criteria for ME/CFS.

In new guidelines on ME/CFS in 2021, England's National Institute for Health and Care Excellence decided to no longer recommend graded exercise therapy – fixed, incremental hikes in activity – but to recommend activity and energy management based on pacing, staying at levels that feel right for the individual. This followed a thorough review of all the clinical trials that had involved exercise therapy. People with ME/CFS have been harmed by exercise programmes. We hope those with long covid won't experience the same fate.

Just blame the Romans for the Greek tragedy

10 February, p 29

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

Matthew Sparkes wonders why the ancient Greeks didn't go on to develop greater mechanical marvels than they did. I believe the answer may lie in the changing political forces of the time, as the dominance of the Mediterranean was changing from the science and knowledge-loving Greeks to the imperialist Romans. As far as the latter were concerned, science and engineering needed to be devoted to the engines of warfare and conquest, and anything else was an indulgent diversion.

Still no closer to solving mystery of consciousness

Letters, 10 February

From Andrew Whiteley, Consett, County Durham, UK

Terms like "emergent" and "complex" are often deployed as though they present a clear, simple explanation of mind and consciousness. In fact, we have no idea how, or if, mind arises from mindless material. Equally, to say consciousness is an emergent property of matter implies that this phenomenon is somehow already present in it. Consciousness may not require magic, but it is still highly mysterious.

What does the brain look like when playing a flute?

3 February, p 12

From Ros Groves, Watford, Hertfordshire, UK

It was interesting to read how learning to play the piano causes changes in different brain areas.

Many other instruments produce their notes through different methods from far fewer basic keys or strings, such as varying lip pressures or pressing strings down at different points. Consequently, these are learned largely by associating each printed note with a particular motor movement, with far less recourse to looking at the instrument (as with the piano). It would be interesting to run similar studies to see brain changes in such cases.

Weather calamities are climate disasters

Leader, 10 February

From Michael Paine, Sydney, Australia

Your view on whether the world has already warmed by 1.5°C refers to extreme weather events. The resulting human tragedies are often referred to as "natural disasters" by politicians and the media. But the causes are becoming less and less natural. Let's start calling them what they are – "climate disasters".

Book sorting is far from tedious to me

3 February, p 44

From Sam Edge, Ringwood, Hampshire, UK

I liked David Robson's piece on subverting memories of a work session by ending with a fun task. But the assumption in a study he cites that the supposedly onerous tasks of isometric exercise, book sorting and dealing with customer complaints are "tedious" is very subjective. I get great satisfaction from sorting books and indeed many other tasks that bring order from chaos. Others enjoy bodybuilding. Resolving people's problems is rewarding to some. Eye of the beholder and all that!

Hiking car costs wouldn't be fair for rural areas

Letters, 3 February

From Pamela Manfield, The Narth, Monmouthshire, UK

While I worry about excessive car use, let's not forget that only in cities or large towns would you have a choice of alternative methods of transport if car use were to be made more costly. In rural areas, an affordable car is vital, as public transport is limited or non-existent. You could have food delivered, but you can't get to a doctor or dentist without a car. ▮

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What technology means for us

An ambitious exploration of our relationship with technology makes for interesting reading in the age of AI, finds **Sandrine Ceurstemont**

Book
Wise Animals
Tom Chatfield
Pan Macmillan

IN 1770, inventor Wolfgang von Kempelen claimed to have created a machine that could skilfully play chess against human opponents. Known as the Mechanical Turk, his contraption defeated many challengers, including Napoleon Bonaparte and Benjamin Franklin, and caused much amazement and debate about how it worked. It was eventually exposed as a hoax, however, with a human chess master hiding inside.

The Mechanical Turk raises intriguing questions about how humans perceive technology, says philosopher Tom Chatfield in *Wise Animals: How technology has made us what we are*. For example, we may often have incorrect assumptions about what a machine is doing. As he writes: "We're only too keen to attribute human-like autonomy to machines, in the process forgetting how much they depend on their makers and maintainers."

Every part of our lives is a result of humans co-evolving with tech

Now, artificial intelligence can actually beat human players at chess and engage in human-like conversations, with the advent of a new generation of chatbots such as OpenAI's ChatGPT. As AI advances, our desire to anthropomorphise technology has reached new heights, and Chatfield delves into the implications of this phenomenon.

Some have claimed, for instance, that current chatbots could be conscious, suggesting they may have their own intentions, which could put humans at risk. And when it comes to online content, it is becoming harder to distinguish between deepfakes and real images, videos and audio, creating ethical issues about trust and transparency (see page 14).

Throughout his book, Chatfield encourages readers to consider technology and our relationship with it in different ways. The first part covers our technological past in its broadest sense. The term technology is used to describe all human-made artefacts, including clothing and the written word, and Chatfield explores how we co-evolved with our inventions.

The second part examines different philosophical perspectives that often aren't considered when we debate

"Notifications lure us into using email instead of making a call or doing something else entirely"

the role of present and future technology. Overall, Chatfield aims to help readers keep an open mind about the possibilities, stressing that the way innovation has progressed wasn't the only way it could have developed. He also makes key points about how technology is shaping us in ways that aren't always obvious.

AI is far from neutral. It has been trained on our biased data and systems, such as face recognition systems that struggle to work for people with darker skin.

The way technology is designed also makes demands on our attention and time. For example, notifications lure us into using email instead of making a call or doing something else entirely. "What assumptions and predictions are our minds being pushed towards by the systems they're enmeshed in: by their interfaces, abstractions and automations?" asks Chatfield.

Wise Animals is ambitious in its scope. Its references are broad, from the writings of ancient Greek philosopher Plato in *Phaedrus*, where he outlines the dangers of writing because words on a page can be misinterpreted in a way they can't when spoken, to the book *Transcendence* by journalist Gaia Vince, which describes how our evolution is shaped by genes, environment and culture.

Some of Chatfield's arguments are repeated in different chapters, and it feels like he is rounding up previous ideas rather than developing them and providing fresh insight. However, he does offer a good overview of the complex nature of our relationship with technology.

Looking to the future, Chatfield is hopeful about developments in technology that could help us address challenges and enhance our lives. He focuses on human-machine collaboration rather than rivalry. As for machine superintelligence posing an existential risk to humanity, he emphasises the differences between humans and AI. For example, even though they can produce similar outputs, the process each uses is different. A machine has no intentions or desires and is engineered by people for particular purposes.

Hopefully, it will stay that way.

SHUTTERSTOCK/INTERSTID

Sandrine Ceurstemont is a writer based in Morocco

The persuaders

Could you get someone to change a deeply held belief? A new book has some intriguing lessons, finds **Alison Flood**

Book

Supercommunicators
Charles Duhigg
Cornerstone Press

BRANDON BELL/GETTY IMAGES

A member of the US National Rifle Association argues with gun control advocates in Texas, 2022

WHAT happens when you put dozens of gun-control activists and gun-rights advocates in a room together and leave them to talk?

Writer Charles Duhigg's new book *Supercommunicators: How to unlock the secret language of connection* takes us inside that room as he introduces us to the potential power of conversation through his riveting stories. We also meet the antivaxxers who are persuaded by a doctor to vaccinate their kids, and the FBI negotiator who could persuade anyone to do anything, including getting an animal smuggler barricaded in a room with an iguana, six cobras and 19 rattlesnakes to give up – and name his accomplices.

What about persuading people whose beliefs are implacably opposed to hear one another out? One such "experiment" took place in Washington DC in 2018, intended to see if people who loathed each other's beliefs on guns could ever have a civil conversation.

Organisers divided participants into small groups, asking one person in each to describe a personal challenge. Listeners asked questions, summarised what they had heard and asked the speaker if the summary was accurate. The next stage was to apply this technique to guns, explaining why the issue was so important to them.

It worked. The connection they felt after sharing details from their lives and the experience of really being listened to meant that people with diametrically opposed views could have honest conversations about guns, without them ending in shouting matches. Views didn't change, but the approaches did.

Duhigg's excellent book aims to explain how conversations work so we can connect more meaningfully in our relationships. He lays out three basic types of conversation: emotional ones, ones about identity and practical, decision-making ones. Our mindset is different depending on the conversation type, so it is crucial to identify which one we are, in fact, having. Conflict, as Duhigg explains, will ensue if one person is speaking emotionally ("Jim is driving me crazy!") and the other is being practical ("What if you just invited him to lunch?").

> **"Duhigg aims to explain how conversations work so we can connect more meaningfully in our relationships"**

Realising what is going on gives us the potential for neurological synchronisation, when our brains, to a certain extent, align. Duhigg describes some fascinating studies. Take the Princeton University researchers who used functional magnetic resonance imaging to measure the neural activity of 12 people as they listened to a recording of a woman telling a story about her prom night. Their brain activity synchronised with that of the narrator as they listened.

Some are better than others at neurological synchronisation: they are Duhigg's "supercommunicators". From asking deep questions (not "where do you work?", but "what's the best bit of your job?") to judging the mood and energy of your conversation partner, he details what they can teach us.

As you would want in a book on communication, Duhigg is clear and engaging, linking research with his own interviews as he explores what really happens in a successful – or difficult – conversation. Some sections can feel repetitive, but Duhigg's advice on how to confront the toughest topics is welcome in our polarised times.

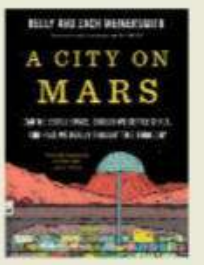
Back with that FBI negotiator/supercommunicator. "The key was getting him to see things from the snakes' perspective," he tells Duhigg. "He was a little weird, but he genuinely loved animals." ▮

New Scientist *recommends*

James Dinneen
Reporter
New York

I really enjoyed **A City on Mars** (pictured) by Kelly and Zach Weinersmith, a hilarious and forthright look at the practicalities of living in space. The science-writing duo argue that enthusiasts have focused so much on the technical challenges that they have overlooked the many biological, psychological and legal barriers to colonising outer space.

For instance, any long-term human colony needs reproduction. But how well does pregnancy work in low gravity? Or sex, for that matter? Or early child development?



The Weinersmiths argue that we have no idea. They are opinionated, but always fair. The book should be welcomed by space-dreamers and sceptics alike.

I am also halfway through **True Detective: Night country**. The new season features Jodie Foster as a cantankerous police chief in Alaska trying to make sense of the icy death of a group of geoscientists. I expect nightmares until the very end of the mystery.

The TV column

A bumpy ride

Astronaut Jo Ericsson is alone on the International Space Station after a mysterious object hits it. Nothing is what it seems in *Constellation*, a show with frustratingly off-piste science. Still, it looks amazing, says **Bethan Ackerley**

Bethan Ackerley is a subeditor at *New Scientist*. She loves sci-fi, sitcoms and anything spooky. She is still upset about the ending of *Game of Thrones*. Follow her on X @inkerley

APPLE TV+

Astronaut Jo (Noomi Rapace) with daughter Alice (Davina Coleman)

WHAT kind of life would you rather have: one filled with ecstatic highs and dizzying lows, or one of middling satisfaction, free from disappointment?

I suspect most astronauts would opt for the former, while risk-averse normies like me plump for the latter. I ask because I find myself fixated on a series about an astronaut, a show of such varying quality that it frustrated and delighted me by turns.

Constellation, an eight-parter from Apple TV+, is a psychological thriller that follows Jo Ericsson (Noomi Rapace), an astronaut with the European Space Agency living on the International Space Station, away from her husband Magnus (James D'Arcy) and daughter Alice (Davina Coleman). A mysterious object strikes the ISS, damaging its life support systems and leading to the death of commander Paul Lancaster (William Catlett), so the crew is forced to evacuate in one of two Soyuz escape capsules.

The other capsule is damaged and Jo must stay, alone, to fix it, as her oxygen supply dwindles. Racing to secure her way home, she is plagued by visions and her memories falter. Spookier still, we see glimpses of her in another time and place, dragging Alice through a snowstorm to a cabin.

Back on Earth, NASA scientist Henry Caldera (Jonathan Banks) is desperate to retrieve an experiment from the ISS. He and his team are seeking a new state of matter, a condensate that – for reasons we aren't privy to – can only be formed in space.

If you found that sentence frustrating, you will have a hard time with *Constellation*: its scientific allusions are grandiose, but they are rarely anchored in a recognisable reality. At best, these start to explain what is happening to Jo. At worst, they don't make a lick of sense, particularly when Caldera hints at the specifics of the experiment. Hearing an actor of Banks's calibre chew through the exposition, such as it is, will probably set your teeth on edge.

> "The idea of the ISS as a haunted house, cracking under 20-plus years of service, is compelling"

There were times when I wanted to stop watching. Yet what kept me going (beyond my sacred duty as a TV critic) was the series' knack for arresting images. The uncanny figments conjured by the show's directors – Michelle MacLaren, Oliver Hirschbiegel and Joseph Cedar – stayed with me, from the object that hits the ISS to a bloody shroud that drifts across the space station. They call to mind dramas like *Twin Peaks*, composed like paintings and led by the eye.

Compelling, too, is the idea of the ISS as a haunted house, cracking under 20 years of service. As Jo floats through it, you fear for her. Yet Rapace walks the line between fear and flint-eyed clarity, credible as a smart leader unmoored by her experiences.

Constellation is one of the most exasperating, incoherent shows I have watched lately. I was irritated by its scientific posturing, yet drawn in by a bold premise and a mystery at its heart. It poses a key question: is consistency all it is cracked up to be? Think of *Constellation* as a TV litmus test: will you be lured into the darkness of space, with all its highs and lows, or opt for milder fare? ▮

TV

Constellation
Michelle MacLaren, Oliver Hirschbiegel, Joseph Cedar
Apple TV+

Bethan also recommends...

TV

The Haunting of Hill House
Mike Flanagan
Netflix
Flanagan's reimagining of Shirley Jackson's seminal novel is one of the finest horror series of recent years.

Shining Girls
Silka Luisa
Apple TV+
After Kirby Mazrachi (Elisabeth Moss) is brutally attacked and left for dead, her reality begins to shift in unpredictable ways.

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Mrs. K, April 2023

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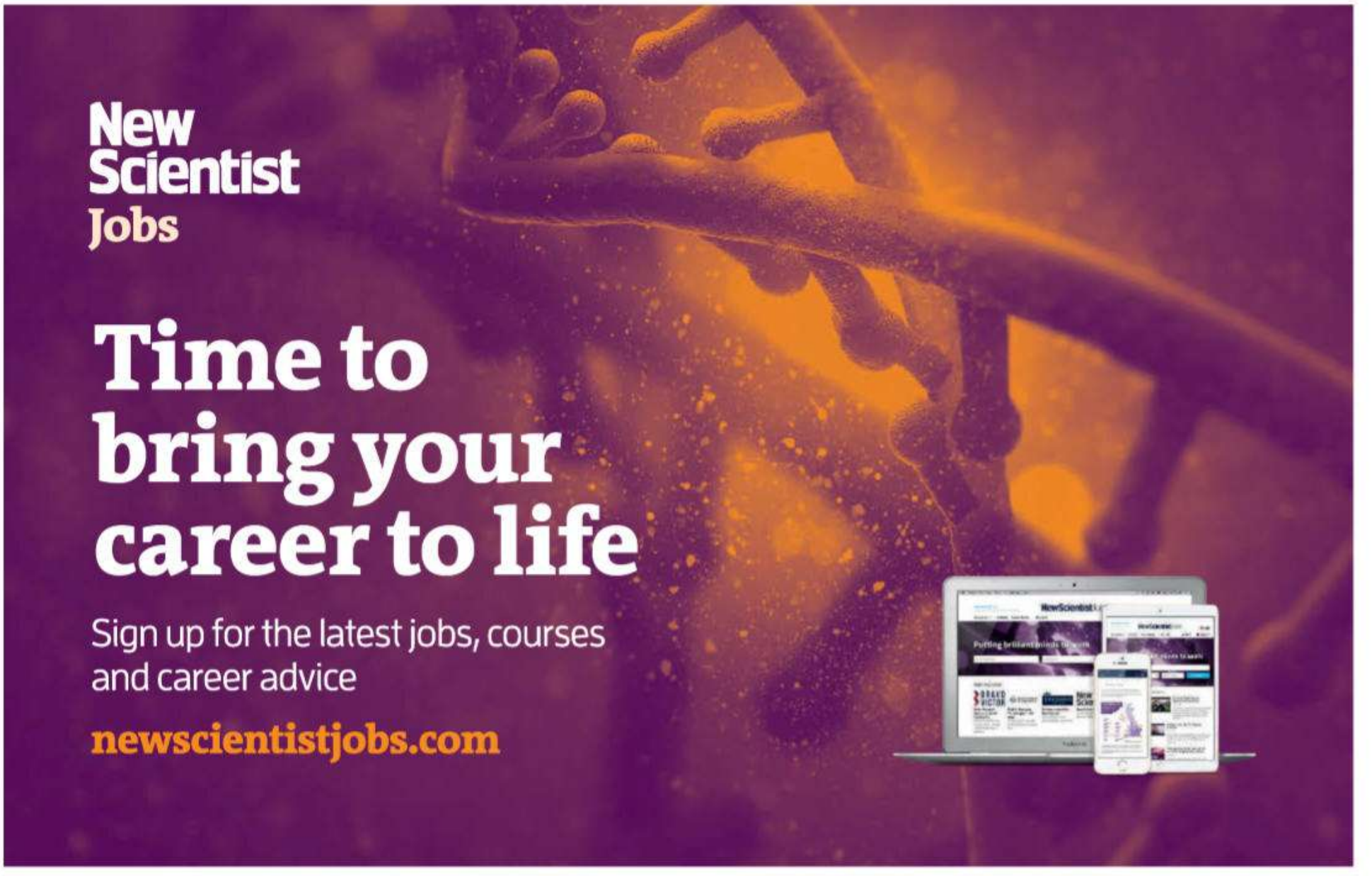
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YOUR AMAZING BRAIN

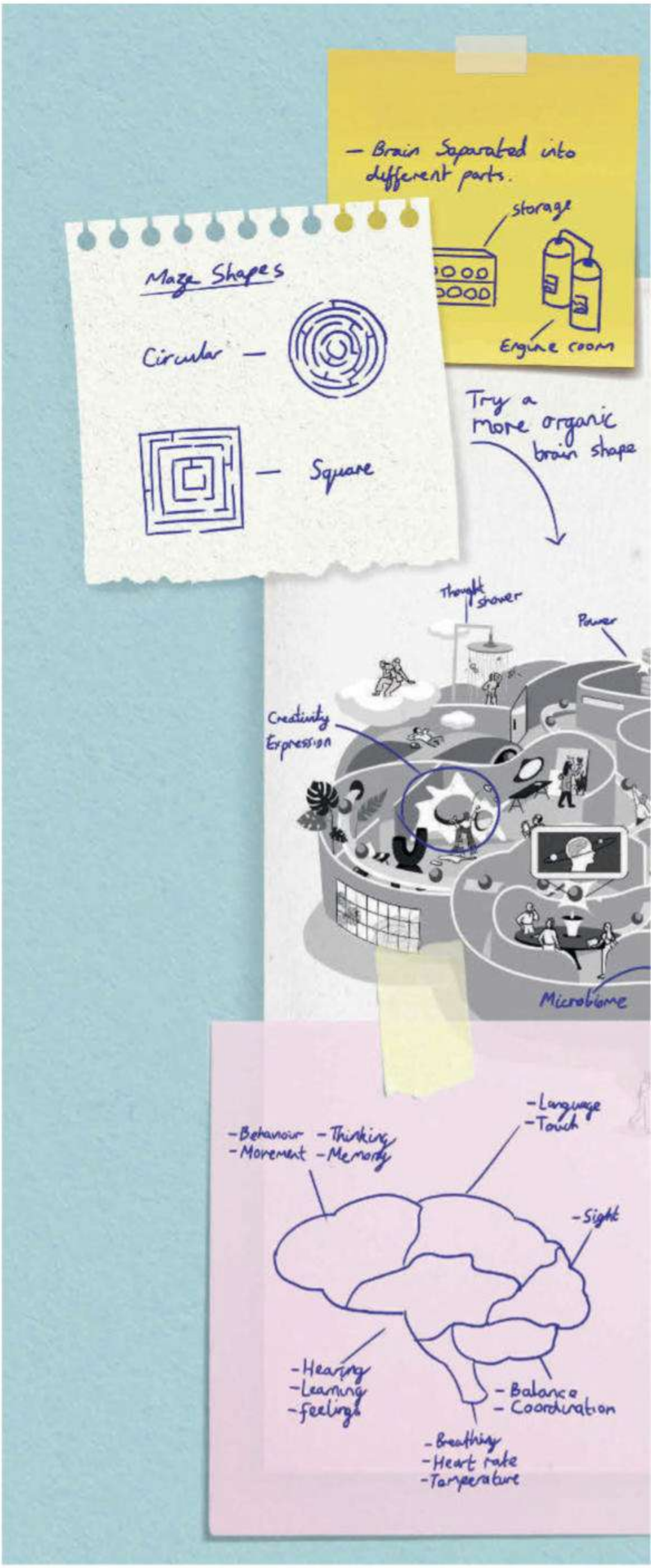
YOU POSSESS ONE OF THE MOST AWE-INSPIRING OBJECTS IMAGINABLE.

THE HUMAN BRAIN IS OFTEN SAID TO BE THE MOST COMPLEX THING IN THE KNOWN UNIVERSE. WELL, WE'LL SEE ABOUT THAT LATER, BUT SUFFICE IT TO SAY THAT YOUR BRAIN IS PRETTY MIND-BLOWING.

YOU WOULD THINK THAT, BY NOW, WITH ALL THE TIME AND EFFORT SPENT STUDYING THE BRAIN, IT WOULD HOLD FEW SECRETS. FAR FROM IT. NEW DISCOVERIES ARE COMING SO FAST, IT CAN BE HARD TO KEEP UP.

OVER THE NEXT 11 PAGES, WE HAVE TACKLED 10 CHALLENGING QUESTIONS THAT HIGHLIGHT THE BEST OF THOSE DISCOVERIES. THESE INCLUDE WHETHER THINKING HARD USES MORE ENERGY, IF THERE IS A DIFFERENCE BETWEEN MALE AND FEMALE BRAINS, WHEN THE BRAIN IS AT PEAK PERFORMANCE AND, YES, WHETHER IT REALLY IS AS COMPLEX AS IT'S CRACKED UP TO BE.

PUT ALL THIS TOGETHER AND IT'S CLEAR OUR UNDERSTANDING OF THE HUMAN BRAIN IS IMPROVING RAPIDLY. TO GET TO KNOW YOURS BETTER, READ ON.



JACK HUDSON

DOES THINKING HARD USE MORE ENERGY?

THE myth that we use only 10 per cent of our brains has been comprehensively debunked. Perhaps it persists because it is so appealing to believe that you could become a genius simply by learning to engage the dormant 90 per cent. In reality, no part of your brain is surplus to requirements, and it is always switched on, even when you are asleep or not thinking about much at all.

But that doesn't necessarily mean that your brain burns the same amount of energy while daydreaming as it does when you are concentrating. We have all experienced that feeling of mental exhaustion after focusing on a tricky problem. Detailed thinking certainly feels like hard work, but is it? The answer is a touch more subtle than you might suspect.

The brain is certainly a hungry organ. "It is the most energy-consuming part of the body," says Nilli Lavie at University College London. Although it accounts for around 2 per cent of our body weight, it uses some 20 per cent of the energy we burn at rest.

Most of this energy is used to maintain different levels of electrical charge across the membranes of neurons – an imbalanced state that needs to be restored after a neuron has fired off a signal. "That requires a lot of fuel," says Ewan McNay at the University at Albany in New York.

Intriguingly, when it comes to energy use, the brain doesn't distinguish between tasks that we traditionally regard as "hard" and those that come more naturally. This was first demonstrated in the 1950s in a study showing that the brain's level of metabolic activity is remarkably constant, regardless of whether we are concentrating on mental arithmetic or letting our mind wander. "Daydreaming takes up neural energy too," says Lavie.

Your brain allocates resources to its different parts depending on the mental activity being carried out. But there is a trade-off. "When the demand of a mentally challenging task increases, you see increased metabolism in the neurons that are responsible for the task," says Lavie. At the same ›

1 NUMBER OF CALORIES USED BY THE BRAIN IN A SELF-CONTROL TASK

time, you see corresponding decreases in other brain areas. For instance, in a study published in November, Lavie and her colleagues measured energy use in the brain region responsible for daydreaming and found that it decreased when volunteers carried out a problem-solving task that required focused attention.

So thinking hard does burn more energy in the brain region involved, but this is offset by energy savings in other parts of the brain. However, the amounts of energy involved are minuscule. For example, a self-control task, such as keeping your hand in icy water for as long as you can, "burns up 1 calorie of glucose", says McNay. However, although this is a tiny amount of fuel, your brain doesn't see it that way. "It worries about an imbalance of supply over demand," he says. If the brain detects local drainage of glucose – the sugar that fuels the brain – it perceives it as something bad, says McNay. This is what gives rise to the feeling of being exhausted after prolonged focus.

One molecule associated with mental fatigue is adenosine, which is a breakdown product of adenosine triphosphate (ATP), the key compound involved in metabolism. "When your brain is burning through ATP, it's producing adenosine and literally signalling to itself: 'Hey, I'm tired now,'" says McNay. Research from 2022 also revealed that thinking hard for several hours leads to the build-up of a compound called glutamate – the main molecule used by neurons for signalling – in the front of the brain. An overload of glutamate is potentially harmful and the brain seems to protect itself by avoiding further mental workout, hence the feeling of mental fatigue.

So, after a tough exam, the sensation of having burned through a supercomputer's worth of energy is real, even though your brain has used few or no extra calories overall. "There is a constant rate of neural energy in the brain," says Lavie. "It is irrelevant whether is it spent on a task requiring concentration or on a distraction." **Alison George**

"THINKING HARD BURNS MORE ENERGY IN THE AREA OF THE BRAIN INVOLVED"

ARE MALE AND FEMALE BRAINS DIFFERENT?

FOR most of recorded history, men and women tended to have different societal roles, interests and occupations. Perhaps it was natural to assume these stemmed from innate differences in their brains, as well as the more obvious ones in their bodies. That idea has long been contentious, but now, with ideas about gender changing faster than ever, the question of whether there are differences between the brains of men and women has taken a keener edge. It remains a divisive issue, even among neuroscientists. Nevertheless, they are finally cutting through the historical discrimination and gender politics to get at the truth.

Early measurements of skull capacity showed that the brains of men are, on average, somewhat bigger and heavier than those of women. Some commentators posited that this "missing 5 ounces" was the key to men's supposedly superior abilities. In fact, the simple explanation is that bigger bodies require more brain tissue to run them – a relationship seen across animal species.

Things got more complicated with the advent of brain-scanning technology in the 1990s, which suggested sex differences in the size of specific brain regions and structures. These findings were often turned into compelling tales about why, for instance, women are more empathic on average, or why men are more likely to be engineers. However, studies from the early decades of brain-scanning research should be taken with a pinch of salt, says Lise Eliot at Rosalind Franklin University in Illinois. "When you control for brain size, all of the claims about volume differences of individual structures between men and women either disappear or become extremely small."

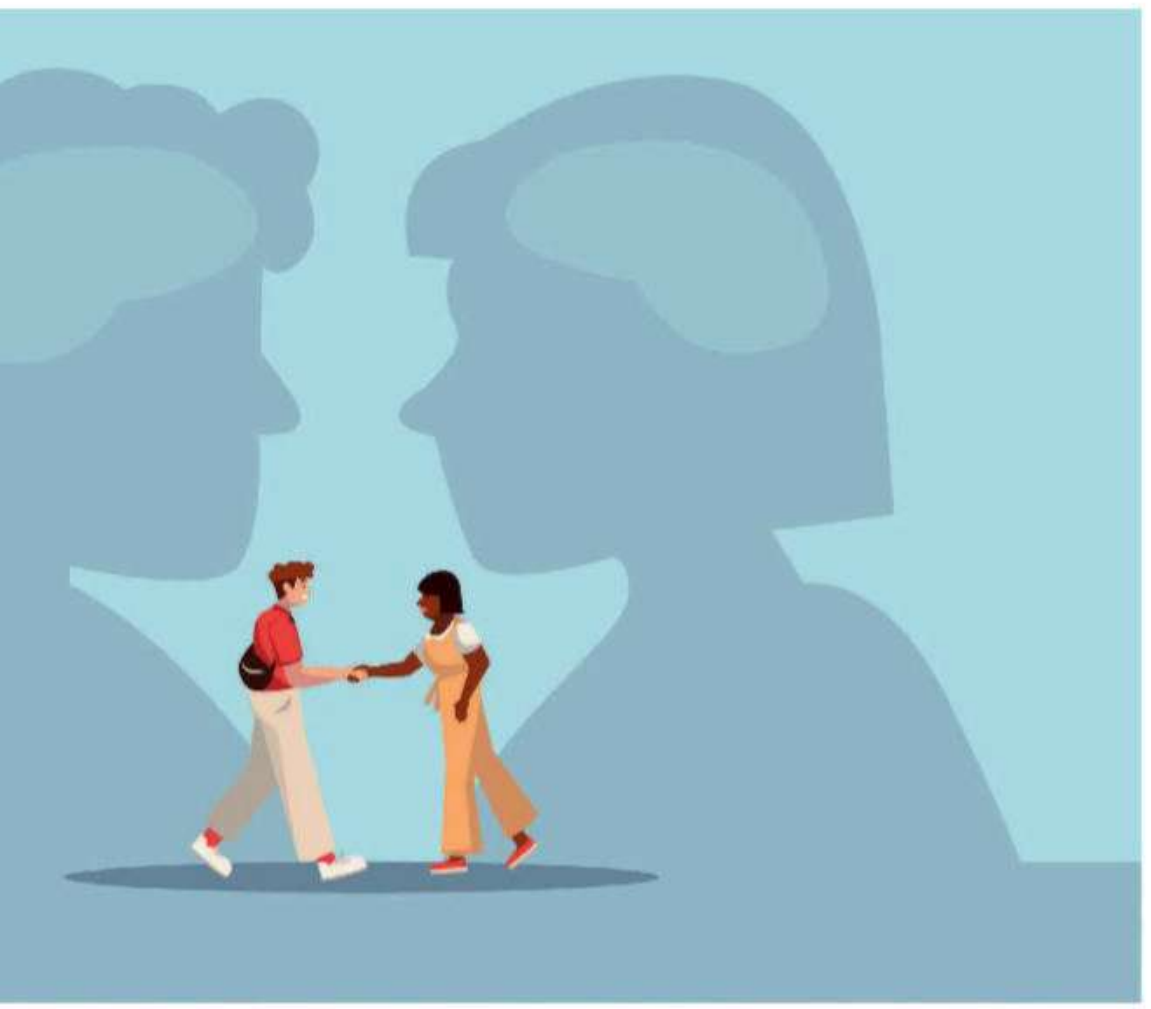
In fact, brain-scanning research has recently had something of an existential crisis. A major analysis from 2022 found that, to be trustworthy, studies need to scan a few thousand people, whereas sex difference research tends to look at just a few dozen. Participant numbers have also been very low in the few studies that have so far explored the brains of transgender people. To cap it all, in a 2021 review

of all past studies of sex differences, Eliot's team found telltale signs of publication bias: scientists who found sex differences have been more likely to publish their work than those who found none.

So should we give up on answering this question? Maybe not. In the past few years, brain-scanning studies have improved. Shortly after Eliot's damning review, the most definitive dataset of sex differences yet emerged from a massive research project called UK Biobank, which has scanned the brains of 40,000 people in the UK. It did reveal sex differences in the size of certain brain structures, even when controlling for total brain size: about a third of regions were larger in men and about a third were larger in women. But these differences were small – generally just a few per cent. "And there wasn't one region that really stood out that might lead to a hypothesis," says Camille Williams at The University of Texas at Austin, who was involved in the study.

What's more, these small differences might not be innate but could instead be caused by the brain responding to life experiences, a phenomenon known as neuroplasticity. We know this happens in other contexts. For instance, if someone becomes blind in adulthood, some of the parts of their brain that deal with vision switch over to processing sounds. So, even if men tend to have a slightly larger part of the brain responsible for, say, spatial skills, that could be because they are more likely to take jobs that involve those activities. In other words, any brain differences between sexes could be a consequence of different gender roles, not their cause.

Neuroscientists are only at the start of their journey of understanding sex differences in the brain. "There are small differences, but we don't know if they're meaningful or not," says Williams. "This is where research should be heading next – trying to understand: 'What do these differences mean?'" **Clare Wilson**



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DOES THE BRAIN HAVE ITS OWN MICROBIOME?

IT SEEMED like a classic case of Alzheimer's disease. For three years, a man in his 70s had experienced serious cognitive decline: he frequently forgot the names of family members and was no longer able to drive or leave home by himself. Further deterioration seemed inevitable. But then his doctors checked a sample of his cerebrospinal fluid and noticed a fungus called *Cryptococcus neoformans*. When they put him on a course of antifungal medication, the results were startling. Within two years, he had regained his driving licence and returned to work as a gardener.

Neuroscientists have long suspected that certain infections can increase the risk of dementia. For instance, both *Porphyromonas gingivalis*, the bacteria behind gum disease, and the herpes simplex virus, which causes cold sores, have been linked with Alzheimer's. But cases of "reversible dementia" are starting to inspire enormous interest in the idea that our brains are teeming with microorganisms – and that an imbalance in this "brain microbiome" may predispose people to neurodegenerative disease.

Until recently, the brain was thought to be devoid of microbes, not least because of the blood-brain barrier, a specialised membrane that keeps pathogens and toxins in the blood out of the brain. So the idea of a brain microbiome was controversial. However, a new study seems to clinch the case. Richard Lathe at the University of Edinburgh, UK, and his colleagues analysed data from post-mortem brains stored in four brain banks in the UK and US. They found a wide variety of microbes, with different types and amounts in different brain regions. Lathe estimates that this brain microbiome contains some 100,000 species, comprising a subset of around one-fifth the gut microbiome. Roughly 1000 "core" species make up 90 per cent of the population.

The researchers also found that, in people with Alzheimer's disease, certain microbes were over-represented. These included species of *Cryptococcus* and *Candida* fungi, *Streptococcus* and *Bacillus* ›

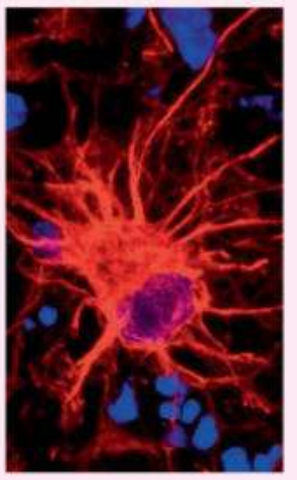
> 3300 NUMBER OF CELL TYPES IN THE HUMAN BRAIN

bacteria, as well as a currently unidentified alga. Although the study hasn't yet been published in a peer-reviewed journal, it chimes with research by Jeffrey Lapides and his colleagues at Drexel University College of Medicine in Pennsylvania. They examined post-mortem brain tissue from 32 individuals and found three distinctive microbial species that were associated with the development of Alzheimer's.

Such findings are intriguing, but there are many unanswered questions. Is a healthy microbiome essential for a healthy brain, as is the case in the gut? Do particular microbes cause neural degeneration or are they a consequence of it? And, if they are to blame, how: do certain species cause harm, is it the overall balance of species that tips someone into illness or do our brains suffer from the crossfire between two competing species, as Lapides suspects? "It could be that the chemical results of that fight are toxic," he says. We don't even know how microbes get into neural tissue, given the blood-brain barrier.

Clues are starting to emerge, though. Take *Candida albicans*, a fungus commonly found in our gut where it is kept under control by "friendly" bacteria. Aimée Parker at the Quadram Institute in Norwich, UK, and her colleagues discovered that mice with a weakened gut microbiome were more likely to have *C. albicans* in their brain. In humans, it is possible that long-term antibiotics treatment could set this in motion by upsetting the gut microbiome. Then, when the fungus reaches the blood-brain barrier, research shows it can spew out chemicals that loosen the barrier membrane, allowing the fungus to enter neural tissue. This appears to trigger the production of a chemical called amyloid beta, which prompts the brain's immune cells, known as microglia, to combat fungal growth. If this process goes awry, the amyloid beta might build up into the plaques associated with Alzheimer's, suggests Parker.

As yet, we have just a faint pencil sketch of the brain's microbiome. There is still much to be discovered – including treatments that specifically target unbalanced microbiomes. Then, many more dementias may be reversible. **David Robson**



NIH/IMAGE POINT FR/BSIP/ALAMY

MARTIN PARR/MAGNUM PHOTOS

Astrocytes (above) play key roles in brain function, including in spatial memory, like that used to play chess (below)

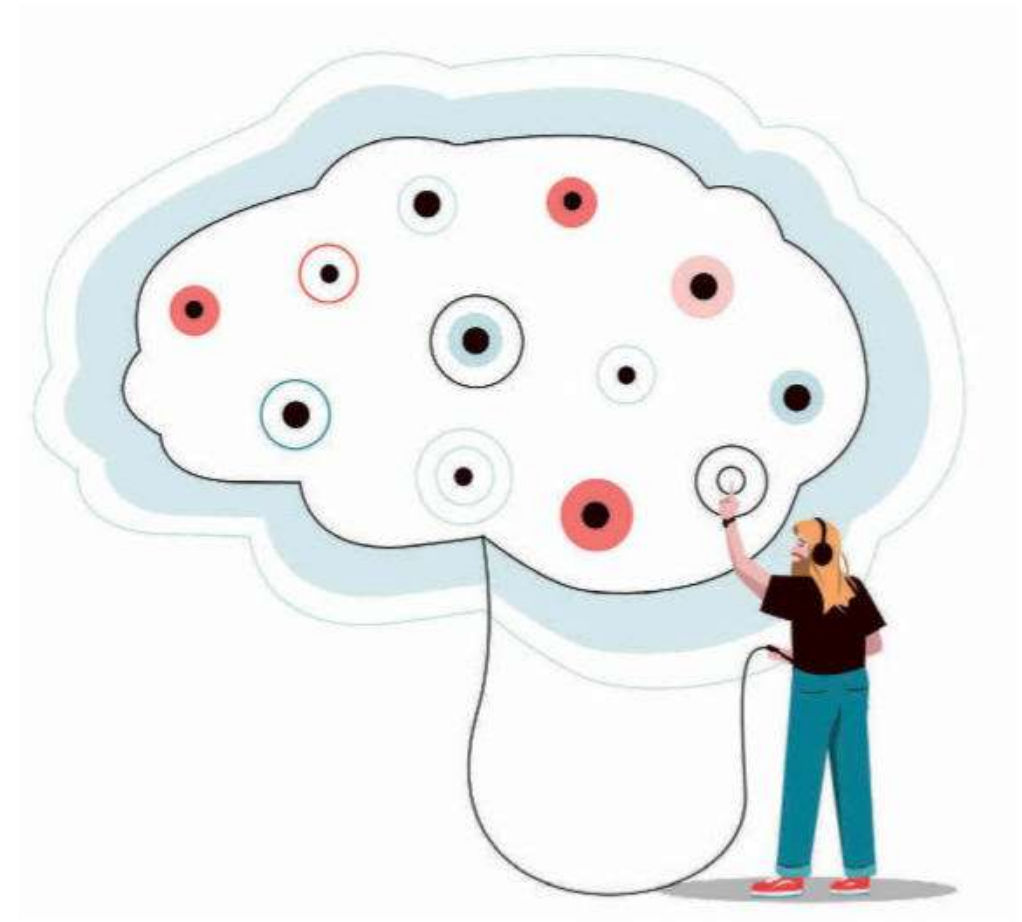
WHAT ARE BRAINS REALLY MADE OF?

IT IS strange to think that we still don't know what our brains are made of. Yet, despite decades of research and the development of high-tech scanning techniques, that is the truth. Sure, we know the basics. The average human brain weighs approximately 1.4 kilograms and has the consistency of soft tofu. It is made up of two general cell types: neurons, which do the thinking, and glia, which support them. But beneath this simple description lies a mind-boggling complexity – a complexity that continues to surprise even neuroscientists.

Everyone knows neurons, the cells that send electrical impulses between different areas of the brain. Your brain contains around 86 billion of them and they come in many different varieties depending on their shape, function and properties. But there is still a lot we don't know about them. Take rosehip neurons, which were discovered in 2018. Named for their shape, the cells seem to damp down the electrical activity of other neurons. Intriguingly, there is no equivalent cell in mouse brains, despite the fact that mice tend to have analogues of other human brain cells. We don't really know much about what they do in the human brain, says Rebecca Hodge at the Allen Institute for Brain Science in Seattle, Washington, who was part of the team that discovered the cells.

Glia, which also number about 86 billion in the human brain, are even more difficult to pin down. Their name is derived from the Greek word for glue and they were long considered to be nothing more than glorified structural support for

"THE CHEMICAL RESULTS OF MICROBE FIGHTS IN THE BRAIN COULD BE TOXIC"



neurons. We now know that glia play some key roles in brain function. For example, one type called oligodendrocytes produces the insulating myelin sheaths that help neurons transmit electrical impulses. Microglia, meanwhile, are the brain's immune cells: they rove around looking for signs of inflammation and other damage and then congregate to clear it. And star-shaped astrocytes help to regulate blood flow in the brain, among other things.

In September 2023, the picture was complicated even further. Andrea Volterra at the University of Lausanne, Switzerland, and his colleagues described a new type of human brain cell that appears to act as a hybrid between neurons and glia. "The border between neurons and glia is much more flexible than initially thought," he says. "Our discovery shows that some astrocytes also have molecular and functional features of neurons." The cells his team discovered seem to be involved in spatial memory, which, for example, allows you to navigate a familiar route. But we are still a long way from fully understanding their role in the brain, says Volterra.

Yet this variety of cell types is just the tip of the iceberg. In March 2023, researchers at the Allen Institute reported results from studies in which they looked at 4.1 million cells from across the brains of mice. They identified an astonishing 5200 different types of cell based on their genetic activity, which indicates a cell's function. The vast majority – some 5000 – were neurons, with glia making up the rest.

Allen Institute researchers and others have since shown that the same technique can be used to map cell types in the human brain. In October 2023, the first draft of an entire human brain cell atlas was published, comprising more than 3300 types of cell. It is the most comprehensive analysis to date, examining the whole human brain rather than just regions of it. Although the resolution is far lower than for the mouse research, Hodge is hopeful that a complete cell atlas is possible. But, she adds, we are still very far from knowing how all these cells connect to each other to create a human mind. "This will take many more years of research to fully understand," she says.

Jason Arunn Murugesu

WHEN IS THE BRAIN AT ITS PEAK PERFORMANCE?

THOMAS EDISON is said to have held a steel ball in each hand as he prepared for a nap. When he nodded off, they would drop, waking him and allowing him to capture the ideas he had in the moment just before sleep – a period he believed to be one of the most creative. But are there really certain times when our brains perform better? And, more broadly, do we excel at different sorts of thinking at different stages in our lives? If so, it is worth asking how we can make the most of these mental peaks and push our brains' abilities to the max.

While Edison's method may have been unorthodox, it turns out he was onto something, as Delphine Oudinette at the Paris Brain Institute and her colleagues discovered in 2021. They gave 103 slightly sleep-deprived people a seemingly complex maths problem that could be solved with a simple creative insight. Participants who had been woken just after falling asleep were almost three times as likely to make the creative leap and solve the problem than those who remained awake throughout the experiment.

This knowledge may help if you are looking for inspiration. But if it is memory you are trying to optimise, then deep sleep is when your brain does its heavy lifting – laying down new long-term memories from your day's experiences. To make the most of this, you need enough sleep, which for adults varies between 7 and 9 hours each night. If you are among the many people who fall short, getting more sleep is a simple way to boost memory and learning. It will also improve attention, decision-making and mood – and even reduce your risk of cognitive decline over the long term.

Assuming you got enough sleep the night before, what happens to your brain power over the course of the day? In general, cognitive performance declines the longer you are awake, with a molecule called adenosine building up and generating "sleep pressure". As a result, your performance tends to follow a predictable path: it is highest in the morning, peaking at around noon, then it starts dipping and, aside from a slight peak in the afternoon, it is downhill all the way to bedtime. This pattern is somewhat shifted by our individual "chronotypes". Natural "larks", who tend to wake early, follow it most closely; "owls", who go to sleep late and wake later, reach their cognitive peak later in the day.

Along with this daily rhythm, there are peaks ›

and troughs over the course of a lifetime. Contrary to popular belief, the brain's performance doesn't simply decline from early adulthood onwards. A series of experiments in tens of thousands of people found that while problem-solving ability is highest in our 20s, other important mental skills mature later. For example, working memory peaks at around 30 and emotion perception is highest from your 40s to 60s, while comprehension and information-processing abilities reach a zenith at around 50 and remain high for decades thereafter.

Whatever the time of day or period of life, there is still a way to get more from your brain: flow. Hungarian-American psychologist Mihaly Csikszentmihalyi first described it as "a state in which people are so involved in an activity that nothing else seems to matter". In other words, this is pure focus. One recent study suggests that the brain network activity linked with the flow state is organised in an energetically efficient way. "This might explain why flow feels effortless," says Richard Huskey at the University of California, Davis.

Flow is more likely to occur if you are undertaking a task with clear goals, immediate feedback and a balance between challenge and your skill level. Although people's tendency to experience it seems to be partially heritable, there may be ways to cultivate it. One of these is mindfulness – paying attention to your thoughts and bodily sensations. Given the other potential benefits of mindfulness, it may be worth a try. **JAM**

ARE THERE DIFFERENT STATES OF CONSCIOUSNESS?

WHAT is consciousness? This is arguably the biggest remaining mystery of the human brain. No wonder it is known as "the hard problem". We can't even agree whether consciousness is one thing or a variety of different states. However, new ways of exploring that question shed some intriguing light on this most elusive of concepts.

Though we use language like "losing consciousness" for fainting or falling asleep, researchers have long understood that consciousness is more complicated than just flipping a metaphorical switch from "on" to "off". However, there is still much debate over whether it is a single phenomenon with many continuous shades, which you might picture as a dimmer switch, or a collection of discrete states, like separate television channels.

Thinking about consciousness from the perspective of a physicist may help resolve the question. That's because the brain constantly shifts between states defined by patterns of electrical signals, and physicists have metrics for examining such busy, ever-changing systems. In 2014, Robin Carhart-Harris at the University of California, San Francisco, and his colleagues hypothesised that entropy may be a particularly useful one. Entropy describes how disordered a system is. One measure of entropy is how many different microscopic configurations (such as arrangements of water molecules in a glass) there are in a given macroscopic property (such as the volume of that glass). The researchers proposed that brain states with greater entropy, as measured by the variety and number of electrical signals and connections between different parts of the brain, are richer in information. This suggests there is a spectrum of consciousness with some minimum level of brain entropy necessary for any consciousness at all.

Some facets of this hypothesis have been tested by calculating the brain's entropy from brain scans. For instance, several studies show that consuming psychedelics can increase the brain's entropy. Others

100,000 NUMBER OF SPECIES IN THE BRAIN'S

"ADOLESCENTS TEND TO OUTPERFORM ADULTS IN SITUATIONS THAT ARE MORE UNCERTAIN OR VOLATILE"

reveal that people's brains have less entropy during deep sleep than they do while awake.

Gustavo Deco at Pompeu Fabra University in Spain and his colleagues have used another idea from physics, equilibrium, to explore consciousness. A physical system is in equilibrium when in its most stable state. The researchers wanted to know how close to equilibrium the electrical states of the brain were while people performed different tasks. Using a mathematical theorem devised by Albert Einstein along with information from neuroimaging, they found that the brain is closer to a state of equilibrium when people are gambling than when they are cooperating. Again, the equilibrium approach seems to suggest that there are many shades of consciousness.

Perhaps unsurprisingly, not everyone agrees. "The idea that there is a single scale for measuring consciousness, the dimmer switch idea, is oversimplified," says Dan Lloyd at Trinity College in Connecticut. He argues that conscious states are more likely to correspond to a multidimensional scale because consciousness is fundamentally related to subjective experience, and an individual's experience has so many different facets depending on their senses and environment. He gives the example of psychedelic drugs. "Psychedelics are going to change your sentience, but it's not like, now I'm more conscious or less conscious than I was before, I'm differently conscious." The increased entropy of the brain on psychedelics captures something of that difference, but we don't yet have a good enough theory of consciousness to qualify it further, he says.

David Papo at the Italian Institute of Technology points out that even scientists from different fields have different notions of what consciousness is. "How can one find an appropriate quantifier for some fuzzily defined concept?" he says.

Deco admits that none of his experiments have fully tested the dimmer switch idea because they are designed to observe one state at a time to make the results unambiguous. How the brain transitions between states isn't clear. Nevertheless, he believes that approaches inspired by concepts in physics like equilibrium and entropy have the potential to quantify such properties of consciousness and will be crucial for determining whether it is a continuum or a collection of separate channels.

Karmela Padavic-Callaghan

MICROBIOME

PM IMAGES/GETTY IMAGES

Is consciousness a collection of discrete states we flip between?

HAS THE TEENAGE BRAIN EVOLVED FOR A PURPOSE?

TEENAGERS, eh, what are they like? They have a reputation for being difficult, reckless and self-absorbed, but surely these negative stereotypes can't be the whole story. Most other animals fly the nest soon after puberty, and none, including our closest primate relatives, has the prolonged adolescence that we do. Why would humans have evolved this peculiar life stage? A closer look at the teenage brain suggests it brings a hidden evolutionary advantage.

The past two decades of research has emphasised that the cerebral cortex, the brain region central to higher processing and cognitive control, continues to develop until our early to mid-20s. By contrast, regions that are sensitive to rewards – including an area called the ventral striatum – are firing on all cylinders by our mid-teens. This has bolstered the narrative that the adolescent brain is noisy and imbalanced, with its overactive reward system causing erratic, sub-optimal decision-making. Early assessments of adolescent cognitive performance seemed to support this. "Sometimes adolescents would do a task well and other times they would not. It was messy," says Eveline Crone at Leiden University in the Netherlands. However, more recent studies have found that adolescents can be extraordinarily ›

capable – they just need the right kind of task to showcase their skills.

In 2022, for example, Linda Wilbrecht at the University of California, Berkeley, and her colleagues presented 291 volunteers aged between 8 and 30 years old with a computer game in which they had to guess which of two boxes contained a gold coin. First, it would mostly appear in one box. Then, after a random number of guesses, it would start appearing mostly in the other box, before switching again. To do well at the game, participants had to assess the best point at which to shift their guesses from one box to the other. Far from making poor decisions, adolescents aced the test, uncovering more coins than older or younger participants. Teens show a similar aptitude in simulations of foraging tasks, where participants choose between exploiting one plot of land or exploring potentially greener pastures.

"We tend to see these instances where adolescents outperform adults under conditions that are more uncertain or volatile," says Wilbrecht. In such circumstances, adolescents seem more disposed to try new options, which may provide them with information about how to perform well in the future. Parallel behaviours in other species, including our closest primate relatives, suggest this has an evolutionary explanation. As animals make the transition to adulthood and independence, they must learn new skills, travel from their birth site and encounter novel environments. During this uncertain period, it pays dividends to explore your options, with animals that do so having a greater chance of passing their genes to the next generation.

Curiously, more optimal behaviour under such conditions may be linked with greater activity in the reward centres of the brain, which had previously been thought of as dysfunctional in adolescents. Research in Rhesus macaques, for example, has implicated activity in the ventral striatum and amygdala, two components of the brain's reward system, as key to deciding whether to explore new territory during foraging tasks. Activity in the ventral striatum is also associated with better learning in adolescents than children, because the reward signals feed back to the cerebral cortex, strengthening or pruning neural pathways to optimise behaviour. "The adolescent brain is built to explore, discover and connect," says Wilbrecht. "I mean connect in a literal way, because the neurons are reaching out and forming new connections. And we need [feedback from] experience for the brain to be informed about which connections to keep."

Perhaps surprisingly, this optimisation of the adolescent brain extends to social experience, too. In the past few years, it has become clear that the ventral striatum is highly active when working with other people, and adolescents have even greater activity during collaborative tasks than adults and children do. "These social situations rely on that same neural network that is so sensitive in adolescents," says Crone. "So it now seems that the function of the developing adolescent brain is much more socially adaptive than we initially thought." **Tom Leslie**

KERRY WOOLMAN/MILLENNIUM

The adolescent brain is much more socially adaptive than we thought

MID-20S AGE WHEN THE CEREBRAL CORTEX IS FULLY DEVELOPED

40-60 AGE WHEN EMOTIONAL PERCEPTION PEAKS

WHAT MAKES SOME BRAINS SO CREATIVE?

FROM Jane Austen to Albert Einstein, Zaha Hadid to Ai Weiwei, it is easy to name people who have advanced the thinking of humankind – but it is much harder to explain why people like this think so much more creatively than the rest of us. Are their brains just made that way, or can anyone learn to do it? The mystery of creativity has long baffled scientists. Now, researchers are finally making some progress in drawing back the curtain. Better yet, their insights could help us all to exercise a little more original thinking.

Some of the most exciting insights come from the "dual process theory" of creativity, which distinguishes between idea generation and idea evaluation. Idea generation involves delving deep into our existing knowledge for the seeds of inspiration –

perhaps by drawing an analogy from a completely different domain. Free association is key at this stage, as one thought leads to another, more original insight. In the second phase, idea evaluation, we must apply a more critical eye to choose ideas that will best suit our goals. A novelist must decide whether a bizarre, supernatural plot twist will titillate or alienate readers; an engineer must consider whether their fish-inspired plane will be practical and efficient. Any large project requires numerous iterations of these two stages in the long and winding journey from conception to completion.

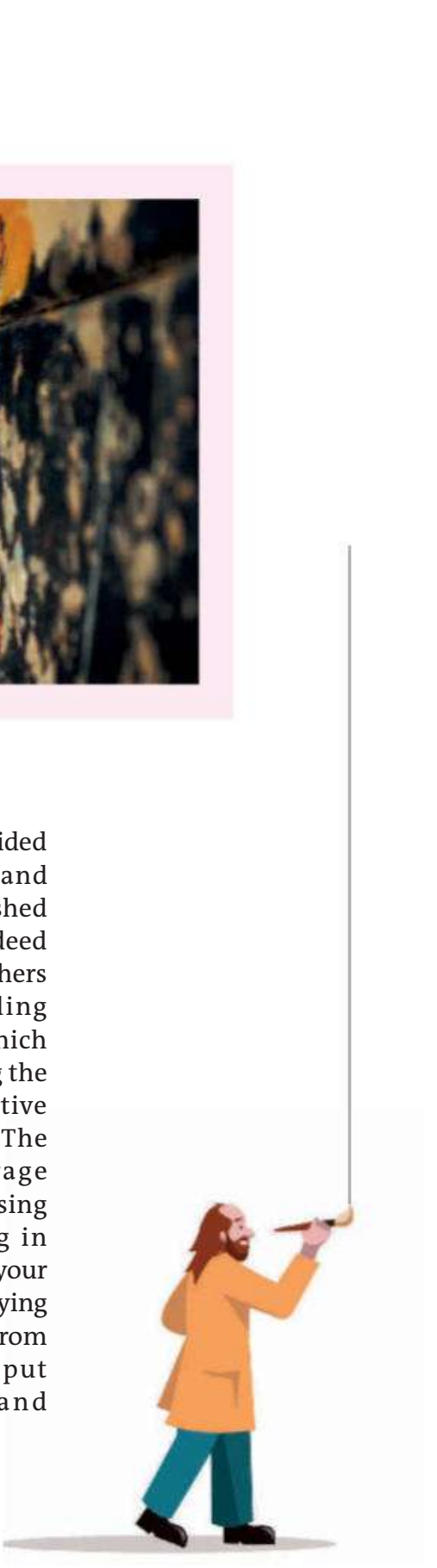
Brain scans of people engaging in creative problem-solving suggest that idea generation and evaluation rely on distinct neural networks. Generation involves the default network, which is typically active when the mind is at rest and wandering from thought to thought. In this freewheeling state, it is able to plumb your memories for inspiration – which may explain why solutions to problems often come when we are in the shower or walking in the park. Idea evaluation, by contrast, seems to rely on the executive network, which is active while we focus on specific goals. A third region – the salience network – may act as a bridge between the two. Its job is to identify the most important or interesting things around us. In a brainstorming session, it might home in on particularly exciting insights before the finer attention of the executive network evaluates them.

Your creative capacity seems to depend on the efficiency of the communication between these different networks. A team led by Roger Beaty at Pennsylvania State University invited 163 people to lie in a brain scanner while performing the "alternative uses task" – a standard test of creativity that involves thinking about novel ways to use a common object, such as a brick. People with the most creative answers tended to show greater connectivity between regions of the default, executive and salience networks. According to a study by researchers at the University of California, Los Angeles, more creative brains also tend to have more random connectivity between distant brain regions. This might contribute to less conventional ways of processing information, generating more original ideas. "That matches with what we see in creative people's lives: they forge their own path," says Ariana Anderson, who led the study.

These findings hint at how you might boost your creativity. Beaty is currently investigating whether training in creative thinking and problem-solving can strengthen connectivity between the default, salience and executive networks. Training programmes might involve, for example, guided practice in idea generation and selection. A meta-study published in 2023 found that this can indeed enhance creativity. The researchers analysed 332 studies, dividing them into 12 categories, of which creativity training was among the most effective and psychoactive drugs had the least impact. The other top ways to encourage creative thinking were practising mindfulness and engaging in cultures that are different from your own, and Beaty recommends trying these. "They help you to draw from different experiences and put things together in new and interesting ways," he says. **DR**

GILAXIA/GETTY IMAGES

Practising mindfulness can increase creative thinking



IS FORGETTING ACTUALLY A FORM OF LEARNING?

THERE are few things more frustrating than trying to recall a fact or memory and finding it has gone missing. You might ask yourself whether it is the start of mental decline or the onset of a degenerative brain condition. What you probably don't think is that forgetting is a good thing. But it can be. New research into memory suggests that it is actually a healthy and necessary brain function – and one that is becoming increasingly important in our rapidly changing lives. "You want to be able to adapt to your environment because your environment is always changing. But if you're ›

WHEN WORKING MEMORY PEAKS

overly fixated on your first experience, you're not going to behave adaptively," says Tomás Ryan at Trinity College Dublin in Ireland. Intriguingly, his research also hints that forgotten memories remain in the brain, so could, if necessary, be restored.

Everyday forgetting – like not being able to recall what you ate for dinner last week – is called natural forgetting. This is in contrast to pathological forgetting, which results from brain injuries or conditions such as Alzheimer's. Far from being a problem, natural forgetting underpins one of our most unique and powerful traits – our ability to generalise. Though there are times when having an ultra-detailed memory is invaluable, like when revising for exams or acting as a witness to a crime, we can't generalise without playing fast and loose with specifics, says Edwin Robertson at the University of Glasgow, UK. "For a chair to be thought of as a chair, it doesn't necessarily have to have wood or leather upholstery, it only requires a few features. Remembering the exact details of a chair is potentially unhelpful because it prevents you from generalising across all instances of a chair."

But natural forgetting may have another advantage. "It's easy to come up with behaviours that you can train an animal or human to do, and then in two weeks' time they have forgotten it," says Ryan. "We've let ourselves think that's just because of time going by and the memory degrading. But actually, over that two-week period, the individual is experiencing all kinds of things and, as a result of those things it's experiencing, it's actually changing its expectations." That matters because expectations play a key role in an emerging picture of the brain as a prediction machine, where conscious experience consists of predictions about what the brain expects to perceive based on what it detects via the senses. This wouldn't work unless the brain could tweak and update its predictions in the form of forgetting, says Ryan.

"FORGOTTEN MEMORIES REMAIN IN THE BRAIN, SO MIGHT BE RESTORABLE"

What's more, research by Ryan and his colleagues challenges the idea that our outdated memories become lost for good. Each memory is thought to be stored in the brain in a suite of physical and chemical changes in groups of neurons called engrams. Using drugs to block the formation of specific proteins in engram cells, the researchers were able to prevent recently formed memories in mice from being stored as long-term ones. Later, when the researchers stimulated the original engrams using optical light stimulation or by presenting the animals with information similar to that which formed them, the memories came back. This suggests that even memories that aren't stored long term still exist in the brain somehow and can be retrieved given the right circumstances.

Stimulating dormant engrams could be a promising route for restoring memory in people who have experienced pathological forgetting. One day, these new insights might even help us to optimise our natural forgetting. For now, they should make us more forgiving of forgetting, says Ryan, because it signifies that you are adaptive to your environment. **Alex Wilkins**

HANS NELEMAN/GETTY IMAGES

Forgetting may be integral to helping our brain remember

86 BILLION

NUMBER OF

NEURONS IN

THE BRAIN

IS MY BRAIN THE MOST COMPLEX OBJECT IN THE UNIVERSE?

BACK in 2012, neuroscientist Christof Koch wrote in his book *Consciousness: Confessions of a romantic reductionist* that the human brain is "the most complex object in the known universe". Given that there are about 86 billion neurons in a brain, connected up in ways that we are only beginning to unravel, this seems intuitive. But when I put it to David Wolpert at the Santa Fe Institute in New Mexico – created in the 1980s as a hub for the budding field of complexity science – he doesn't see it that way. "It's almost farcical to entertain that we are the most complex system in the universe," he says. "The question is actually wrongheaded."

Despite this, I persevere. Surely, there is some common measure of complexity that can be applied to all kinds of intricate systems? After all, if you squint, clusters of galaxies and the filaments that connect them look like tangled circuits of neurons. There are even roughly the same number of neurons in the human brain as there are galaxies in the observable universe. This similarity in form may have something to do with general laws through which complexity emerges, says Ricard Solé at Pompeu Fabra University in Barcelona, Spain. Or it may not. "Coincidentally, that might appear in both systems, but that doesn't mean anything," he says.

Besides, complexity isn't defined by components and their interconnections. It is the idea that the whole is more than the sum of its parts – something that complexity scientists call emergence. In this way, the human brain is more like an ant colony – creating elaborate underground cities without a blueprint or a leader – than a galactic web. Neurons and ants are both relatively simple units that, somehow, collectively give rise to sophisticated behaviour. Solé reckons that the human brain transcended its neurons owing to our unusual capacity for language.

REINHOLD WITTICH/STOCKTREK IMAGES/ALAMY

The Crescent Nebula: more complex than the human brain?

"From our lexicon, we can build virtually an infinite array of sentences," he says. Combined with our memory, this allows us to foresee the future and even imagine alternative futures, as well as the minds of others.

But language, memory and imagination aren't attributes of all complex systems. In 2001, looking for common ground, physicist Seth Lloyd at the Massachusetts Institute of Technology proposed three questions to reveal how complex an object is. First, how hard is it to describe? Second, how hard is it to create? Third, what is its degree of organisation? He went on to list about 40 different measures of complexity that fit into his general framework. "There have been many more since," says Wolpert.

One of these is assembly theory, which determines how evolved any object is by considering how many steps were required to build it, and to what extent this object leads to further complexity. "Human brains make very high-complexity objects in abundance, so, by direct extension, they are the most complex object," says Sara Imari Walker at Arizona State University. Another measure is integrated information theory (IIT), which assesses the amount of consciousness in a system according to how densely interconnected its network is. The human brain is also highly complex by this measure.

Some complexity theorists don't buy into assembly theory or IIT, and all agree that these measures fall short of a general definition of complexity. Wolpert goes further, arguing that the value of complexity science doesn't come from finding a universal measure, but from the diversity of definitions.

So, where does that leave the question of the human brain? Wolpert is in no doubt. It is pure hubris to see it as the most complex object in the universe, he says. "Nothing concerning humans is ever privileged. At best, it's run of the mill – the brain included." ▮

Thomas Lewton

The back pages

Puzzles
Try our crossword, quick quiz and logic puzzle p45

***Almost* the last word**
When living things die, what happens to their atoms? p46

Tom Gauld for *New Scientist*
A cartoonist's take on the world p47

Feedback
A bittersweet ending, and minding your own business p48

Twisteddoodles for *New Scientist*
Picturing the lighter side of life p48

Debunking gardening myths

Time to heal all wounds

Gardening wisdom of the past 50 years has said that painting a tree's pruning wounds is pointless – but **James Wong** isn't so sure

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, in London, he shares his tiny flat with more than 500 houseplants. You can follow him on X and Instagram @botanygeek

IF YOU are a regular reader, you will know of my weird fascination with traditional horticultural practices that endure for decades despite being resoundingly debunked by science. In this article, however, I wanted to explore what might turn out to be a surprising bit of irony. Prepare to get meta...

For well over 400 years, standard horticultural advice was to paint the pruning wounds of tree branches and trunks with various concoctions, in the belief that this would prevent infection and promote healing.

However, as long ago as 1915, scientists began to ask whether contemporary preparations of white lead, coal tar or ochre actually provided the protection they were believed to. By the 1970s, a series of comprehensive studies, which investigated more modern treatments such as bitumen, asphalt and synthetic polymers, demonstrated pretty conclusively that these "wound dressings" didn't prevent decay or speed healing.

The research overturned centuries of dogma. And so, for the past 50 years, the new received wisdom of pretty much every gardening textbook has been that any attempt at treating pruning wounds is long outdated and far inferior to simply letting healing occur naturally.

However, here's the thorny bit: when you look deep into the studies published since the 1970s, a much more complex picture seems to emerge.

WOJCIECH KOZIELCZYK/GETTY IMAGES

First, it is important to point out that this is an enormously complicated question. The rate and degree at which pruning cuts heal depend on the tree species, the type of injury, the time of year when the wound is made and even the type of tool used. That is before we even get to which compounds are used to treat them.

The 1915 and 1970s studies tested very different substances; today, most mixes on the market tend to be natural tree resins or synthetic fungicides – very different preparations from those in the 1970s studies, despite these still being cited as proof that the entire practice doesn't work.

When we consider more recent studies that investigate the use of fungicide pastes, the idea that all treatments are counterproductive becomes harder to sustain. One 2016 trial found significantly higher wound closure rates on trees like ginkgos treated with fungicide versus a control.

A range of other recent experiments have produced similar findings for other plants, such as American oaks and especially grapevines. Perhaps because of this, some academic advice has started to include caveats to the previously strict "no pruning paint" rule, to exclude oak trees.

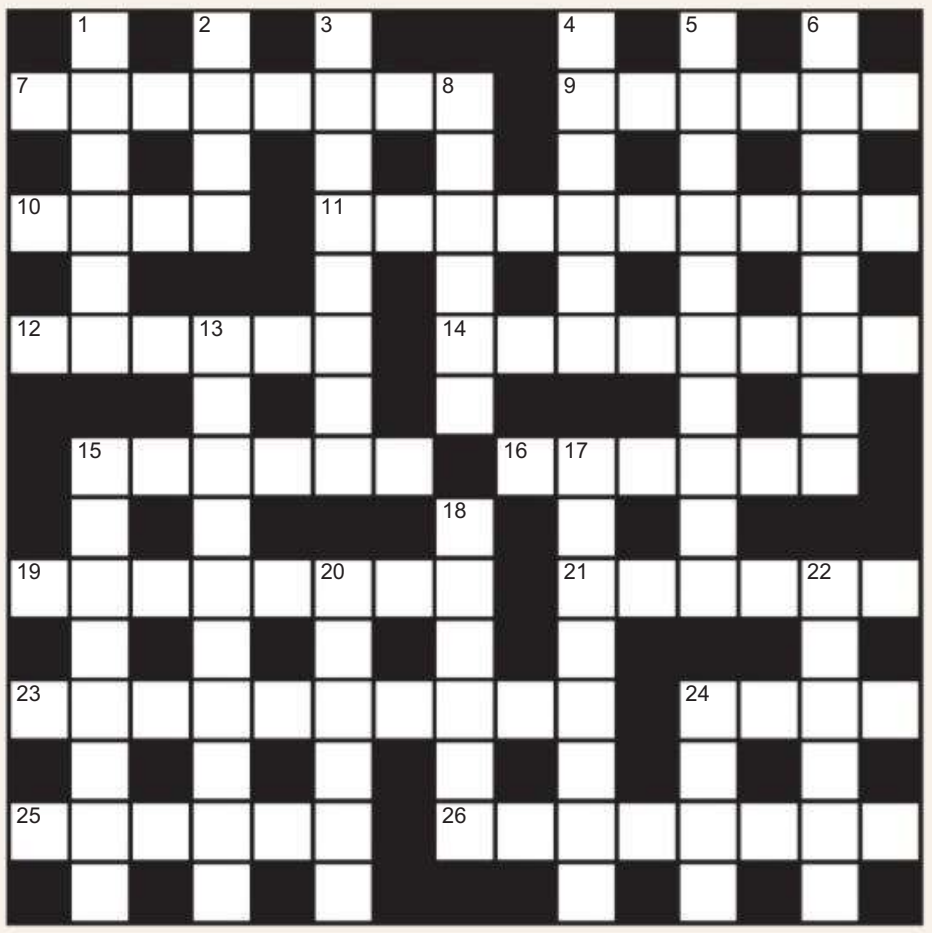
I wonder if, as further research on new treatments is published, the exceptions will one day prove greater than the rule? ▮

Debunking gardening myths appears monthly

Next week
60-second psychology

These articles are posted each week at newscientist.com/maker

Quick crossword #152 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

7 Spiny mammal (8)
9 Warm again (6)
10 Arithmetic problems (4)
11 Yb, Er or Tb, say (10)
12 Part of the large intestine (6)
14 Compound, $C_3H_6N_6$, used in plastics (8)
15 Potassium salt (6)
16 Rocks; pebbles (6)
19 10^{12} (or sometimes 10^{18}) (8)
21 Mountain tobacco (6)
23 Cockpit (6,4)
24 Cupola, perhaps (4)
25 Blood poisoning (6)
26 Sci-fi franchise launched in 1977 (4,4)

DOWN

1 Interstellar cloud (6)
2 Ova (4)
3 Forebrain component (8)
4 Dye derived from lichen (6)
5 Observable event (10)
6 Small, oily fish (8)
8 The genetic material of an organism (6)
13 Cell specialist (10)
15 Non-intersecting (8)
17 Laptop pointing device (8)
18 Altitude, in military code (6)
20 Intelligence assessment (1,1,4)
22 Brownie, for example (6)
24 Soft plumage (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #240
set by Bethan Ackerley

1 What is the visual representation of the number and structure of an organism's chromosomes known as?

2 Name the first fault-tolerant computer.

3 Which of the following brain regions isn't in the brainstem: the pons, the medulla oblongata or the thalamus?

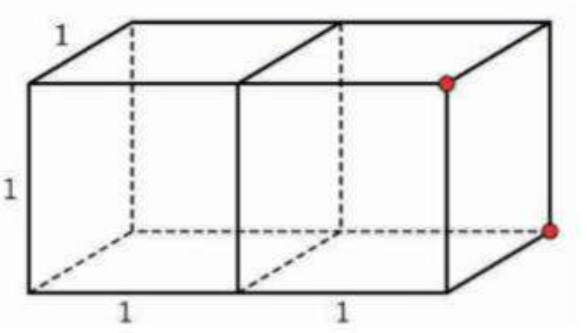
4 What term describes the loss of pigment in an animal that doesn't affect its eyes?

5 In what year was Noether's theorem published?

Answers on page 47

BrainTwister
set by Katie Steckles
#8 Two cubes

A frame is made from two cubes joined together. All edges on each of the cubes measure 1 unit.



What is the distance between the two points on the frame marked with red dots?

Can you find another pair of points on the frame, one for which the distance apart is the square root of 3?

For how many whole number values of n can you find pairs of points on the frame whose distance is the square root of n?

Solution next week

End of the matter

What happens to the electrons, protons, neutrons and photons that exist in living beings when they die?

Pat French
Telford, Shropshire, UK
Short answer – nothing. It is the molecules that are made up of atoms that change after death. The atoms are simply rearranged in less ordered ways. This is called decay and, ultimately, entropy.

Atoms will remain practically unchanged for much of the life of the universe. They will quite possibly become parts of other molecules, only to break down and combine yet again.

For example, a potato contains billions of carbon atoms. It dies when you fry it in your chip pan. Your body then breaks it down into simpler nutrients that you absorb, most of which include carbon atoms. You also produce waste substances, which may contain carbon, that you excrete and then might compost. You also breathe out carbon dioxide, which green plants can use to make sugars and grow. You die, and your carbon atoms help something else grow. Through it all, those carbon atoms are still carbon atoms.

"Only in the final stages of entropy, billions of years from now, might an atom's quarks drift apart in the death of the universe"

Atoms are built from protons, neutrons and electrons. Protons and neutrons are built from quarks. Only in the final stages of entropy in the cosmos, many billions of years from now, might an atom's component quarks drift apart in the "heat death" of the universe – if that is indeed how it shall end.

Herman D'Hondt
Sydney, Australia
Let's have a look at the past lives of the atoms in our bodies. For a start, all hydrogen was created around the time of the big bang. That means all the hydrogen atoms in our bodies are the same age, some 13.8 billion years old. These make up 62 per cent of a person's atoms.

Most of the other atoms within us were created through nuclear fusion in dying stars. As Carl Sagan said, "We are made of star stuff". Hence, all our atoms are at least as old as Earth, i.e. 4.6 billion years.

When we die, our atoms will become incorporated in the environment and eventually in other living beings. It is estimated that every glass of water we drink contains some water molecules that went through a dinosaur and were expelled in its urine. Living bodies may recirculate atoms, but the atoms themselves persist.

How long can we expect these particles to last into the future? Unconfined neutrons undergo beta decay, with a half-life of about 610 seconds, but inside a nucleus they are stable. Electrons may be immortal, as they are the least-massive carrier of electrical charge and hence can't decay under current theories. Some theories suggest that protons may have a limited life. This has been tested experimentally, and so far we have found that, if protons do decay, they won't do so for at least 10^{34} years. That's 100 trillion times as long as the current age of the universe, so not something most people would worry about.

Andrew Murray
Moore, South Carolina, US
All Yorkshire people know that "t'worms'll come an' eyt thee oop". So no atomic particles are lost, just recycled.

ESA/HUBBLE & NASA, DES/DOE/FNAL/DECAM/CTIO/NOIRLAB/NSF/AURA, J. DALCANTON

This week's new questions

Crash course **If the Milky Way were to collide with another galaxy, how would it affect day-to-day life on Earth?** ***PJ Power****, Mullinavat, County Kilkenny, Ireland*

Whale song **Is there any prospect of using machine learning to converse with whales and dolphins?**
Van Snyder*, La Crescenta-Montrose, California, US*

Would life on Earth be affected, if the Milky Way collided with another galaxy?

Tempus fugit

Why do older people seem to experience time passing more quickly?

Alison Edwards
Lydney, Gloucestershire , UK
At age 5, one year was only about a third of the life you remembered, and the three days leading up to Christmas seemed interminable. At 30, a year, now 1/30th of your life, wasn't very noticeable, though every day after your due date felt like a month; at 85, a year is a drop in the ocean, but you become conscious of your gravestone rushing towards you at speed, and of the winds of time blowing your hair out behind you.

Robin Adams
Kintbury, Berkshire, UK
Now in my mid-90s, I can certainly confirm this effect, which I ascribe to each day being a smaller fraction of one's total life experience, and thus appearing shorter.

Perception of time intervals also changes. To me, the new millennium started just the other day, whereas, when I was a young man, the similar interval back to the first world war seemed an age. Memories of the second world war are fresh to me, but to young people today it is as far back as the Crimean war was to the younger me – almost medieval.

Karen Dillon
Via email
The older you become, the more time you have experienced. As you experience more of something, the more used to it you become. This is combined with the lesser quantity of time markers that an adult experiences. A school-aged child has school terms, birthday parties and regular holidays to break time into smaller chunks.

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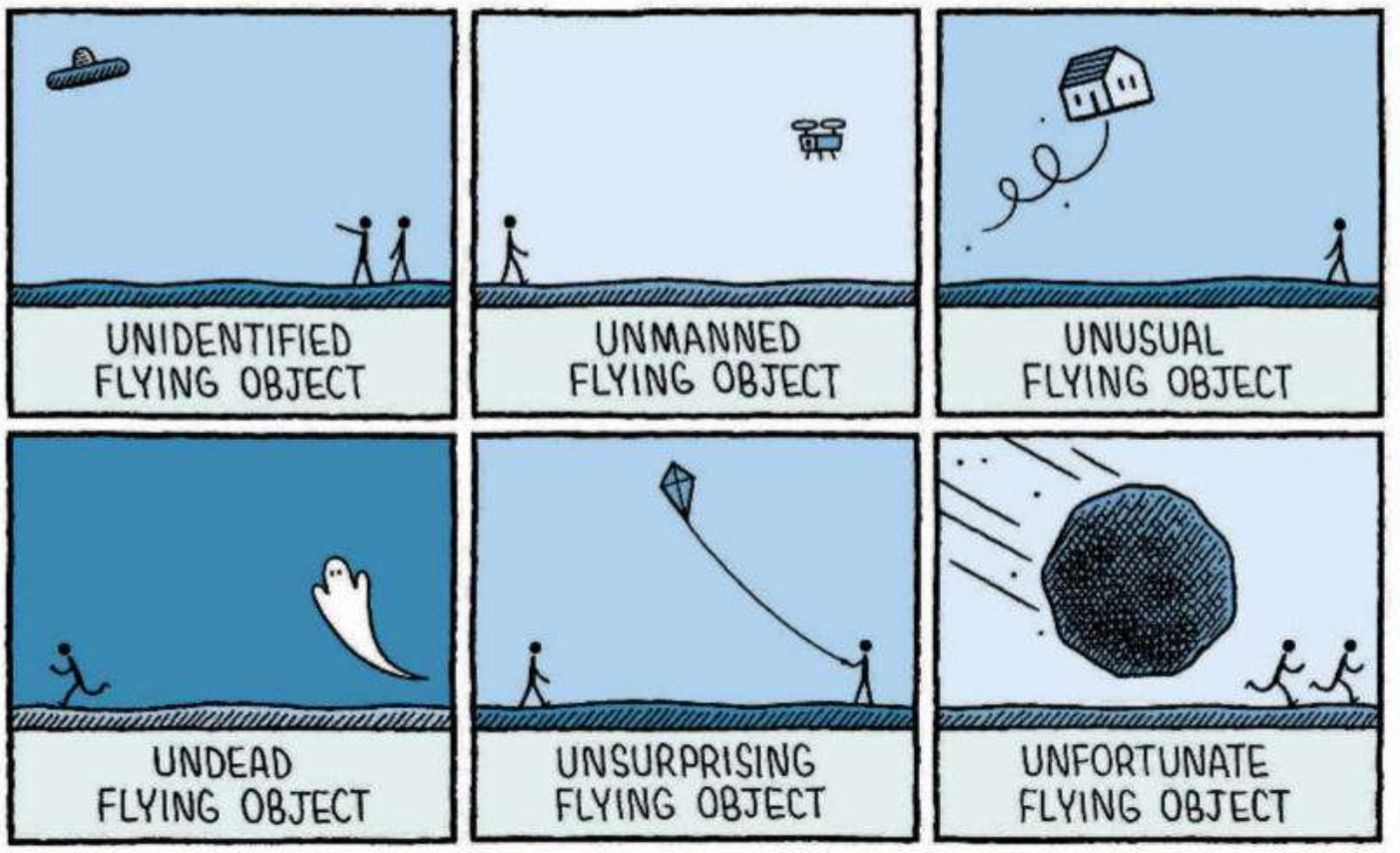
Tom Gauld
for New Scientist



As we enter the workforce, ends of term and the subsequent holidays evaporate.

Mike Follows
Sutton Coldfield,
West Midlands, UK

According to a 2016 experiment, when people were asked to estimate when 2 minutes had elapsed, the average over-50-year-old stopped their clock half a minute after the average 30-year-old, implying that oldies perceive time passing more quickly.

Several biological hypotheses have been proposed. In the 1930s, neuroscientist Hudson Hoagland conducted a series of experiments showing that our perception of time speeds up as our body temperature falls, which occurs due to a slowing metabolism as we grow older. There is a suggestion that mice have shorter lives due to racing through their allocation of heartbeats much faster than we do. Yet perhaps they perceive having a long and fulfilling life, as their high heart rate means mice have a high body temperature.

"As we get older, novel experiences with lots of new information to process become less common and life appears to speed up"

In experiments in the 1960s, the psychologist Robert Ornstein discovered that people perceived time slowing down when they were asked to engage with more complex images or sound recordings. The more information we need to process, the slower time passes. Conversely, as we get older, novel experiences with lots of new information to process become less common and life appears to speed up as we increasingly run on autopilot.

In a 2019 paper, Adrian Bejan at Duke University in North Carolina suggested that the size and complexity of neural networks in our brains increase with age, so electrical signals take longer to travel the bigger distances. He also speculates that damage to our nerves increases the resistance to the flow of electrical signals, slowing them down. As we aren't conscious of a change in the rate of data transfer, we perceive a fall in the transfer rate as an acceleration in the passage of time.

My feeling is that we experience remembered time differently to how we experience it in the here and now. Time might pass quickly when we are enjoying an activity, but it might be remembered as taking longer because it has been recorded in higher definition, so it takes more time for us to retrieve the richer detail.

If I am typical, then time passes more quickly when we are totally focused on an activity and enter a kind of transcendental state. Conversely, time drags when we are bored, as when we lived through the covid-19 lockdowns. With the benefit of hindsight, however, the time spent at home seems fleeting.

Philosophers like J. M. E. McTaggart would have us believe that time is unreal, in which case our perceptions of it changing pace are an illusion. ▮

Answers

Quick quiz #240 *Answers*

1 A karyotype
2 SAPO, built in 1951
3 The thalamus
4 Leucism
5 1918

Cryptic crossword #129 *Answers*

ACROSS 1 Ammonia, **5** Uncle, **8** Prostrate, **9** Awl, **10** Amigo, **12** Trigger, **13** Black-and-white, **15** Rodents, **17** Below, **19** Ash, **20** Aristotle, **22** Ninja, **23** Lyrical

DOWN 1 Alpha, **2** Moo, **3** Network, **4** At a standstill, **5** Uteri, **6** Chargrill, **7** Enlarge, **11** If and when, **13** Bargain, **14** Webster, **16** Nyala, **18** Wheel, **21** Tic

#7 Home primes *Solution*

The home prime of 6 is 23, and that of 10 is 773.

The number less than 20 with home prime 1129 is 15. To get to this, we start with $15 = 3 \times 5$, which becomes $35 = 5 \times 7$, giving $57 = 3 \times 19$, which then becomes $319 = 11 \times 29$, finally leading to the prime 1129.

Sweet or not, the end

Almost everyone who gets old dies.

In a gross way, that brief sentence could sum up a Dutch/Danish/British study called "Use of sugar in coffee and tea and long-term risk of mortality in older adult Danish men: 32 years of follow-up from a prospective cohort study".

The study says: "In total, 2923 men (mean age at inclusion: 63±5 years) were included, of which 1007 (34.5%) added sugar. In 32 years of follow-up, 2581 participants (88.3%) died, 1677 in the non-sugar group (87.5%) versus 904 in the sugar group (89.9%)."

Feedback's nifty, thrifty summary recalls a speech at an Ig Nobel prize ceremony by Yoshiro Nakamatsu. (Nakamatsu, also known as Dr NakaMats, received the 2005 Ig Nobel nutrition prize for photographing and retrospectively analysing every meal he had consumed over 34 years, an activity he continues in 2024.) Nakamatsu said: "Life should be long. Speeches should be short."

Twisteddoodles *for New Scientist*

WE USED TO ONLY RESEARCH TOGETHER. BUT TO SPICE THINGS UP. WE STARTED INVITING OTHERS TO RESEARCH WITH US.
WHERE DO YOU FIND THEM?
SOMETIMES ONLINE. BUT OFTEN AT MEETUPS WITH GROUPS INTO SIMILAR STUFF TO US.
HOW DO YOUR FUNDERS FEEL ABOUT IT?
OH, THEY'RE PRACTICALLY ENCOURAGING IT
@twisteddoodles

Got a story for Feedback?

Send it to feedback@newscientist.com
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Consideration of items sent in the post will be delayed

Shocking news

The practice of mindfulness helps us focus on some particular thing – not just fleetingly, but at length. Feedback cannot stop focusing on a 10-year-old study called "Role of mindfulness-based psychological support during a course of ECT".

ECT is an acronym for electroconvulsive therapy. This study was one of the most successful attempts – perhaps the only attempt – to intentionally combine mindfulness with this therapy.

The researchers report that after being electroshocked, their patients "were cognitively intact to engage in simple mindfulness-based psychotherapy, with no evidence of difficulty with recollection of new information".

They (the researchers), who were then at MidCentral District Health Board in Palmerston North, New Zealand, reached a conclusion that is multisyllabic. They wrote: "This study confirms the cognitive adverse effect-sparing benefits of ultrabrief pulse ECT... but goes on to prove that psychological interventions and physical modalities of treatment are not mutually exclusive."

Mind the dishes

Just a year later, researchers in the US published a study called "Washing dishes to wash the dishes: Brief instruction in an informal mindfulness practice". They had a goal in mind. "We hypothesized," they wrote, "that, relative to a control condition, participants receiving mindful dishwashing instruction would evidence greater state mindfulness, attentional awareness, and positive affect."

They tested their hypothesis on 51 college students, and report that the test was successful. Their study finishes with an appreciation of the big picture, saying: "Implications for these findings are diverse."

Mindful of mindfulness

One can also be mindful about mindfulness. Three researchers (two at the University of St. Gallen, Switzerland, one at the University of Ljubljana, Slovenia) looked mindfully at the heaps of published studies about mindfulness, then published a study about what they think they saw. Their study, called "Exploring the past, present, and future of the mindfulness field: A multitechnique bibliometric review", more or less complains that not many people paid attention to those studies.

The team offers an excuse for why so few people have been mindful of mindfulness research: "low citation rates could also simply indicate that a document pertains to a narrow field of study. Thus, they should not be misinterpreted as evidence of poor quality."

Resisting antibiotics

David Gordon adds his non-prescriptive perspective to Feedback's collection of professional opinions about whether "the art of medicine amounts to entertaining the patient while nature effects the cure".

He says: "All interventions have potential side-effects, so avoidance of unnecessary ones is a no-brainer. As a retired family doctor, I drastically reduced my prescribing of antibiotics by managing the fears... invoked by the symptoms, and explaining the natural history of self-limiting and predominantly viral acute respiratory tract infections; especially for mothers of small children.

"These principles can be applied, judiciously, to other medical scenarios. Unfortunately, this is not good for business, both for the practitioner and the pharmaceutical companies for which one unavoidably acts as an agent. There are fewer 'return visits' to deal with drug side-effects and unalloyed anxieties. More importantly, in the long term, patients are disavowed of the belief that every illness necessitates a prescription."

Losing power

Superpowers – even the trivial ones readers add to Feedback's compendium – aren't all permanent. Grainne Collins confides: "I had a superpower: I could look at any list or table of numbers and know there was a mistake instantly. It might take 10 minutes to work out what, but I was always right. Unfortunately, as my dyslexia has receded (I can now see the difference between 'form' and 'from' without study), so has my superpower!" ▮

Marc Abrahams

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NewScientist

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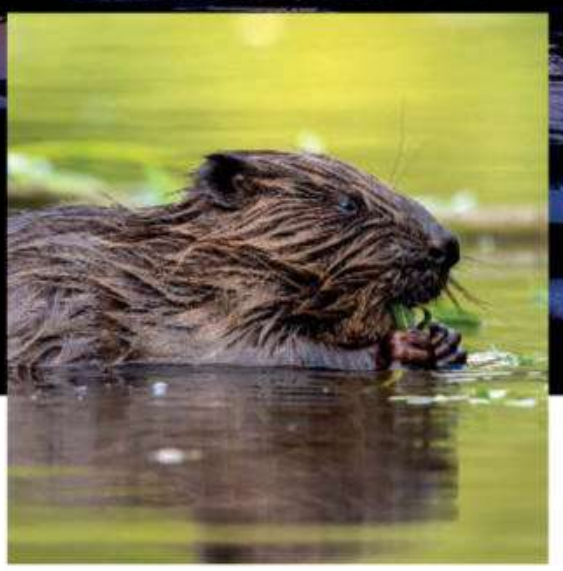
- A private tour of Lyme Regis Museum, former home of fossil hunter Mary Anning.
- Explore the Jurassic Coast by sea on a cruise with a local geology expert.
- Hear from leading experts in geology and palaeontology.



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